MEMOIRS

OF THE

GEOLOGICAL SURVEY

OF

INDIA.

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THOMAS OLDHAM, LL. D.,
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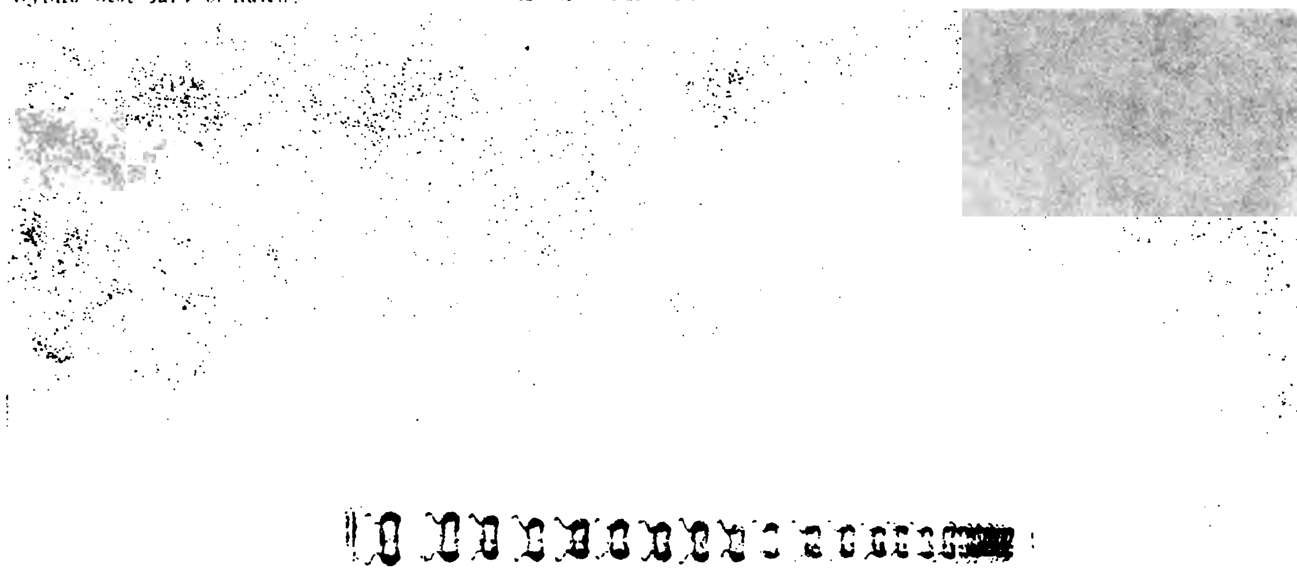

CAMELS CROSSING THE RUNN

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INTRODUCTORY NOTICE.

Those who have followed the progress of Indian Geology know well the great interest attaching to the rocks and fossils of Kutch, and the many doubts which up to a short time since hung over several of the sections there exposed. In previous volumes of the Geological Survey Memoirs these doubts have been fully set forth, and the very high importance which the true interpretation of these sections has, as bearing on the explanation of difficulties in other parts of India, indicated. For these reasons, it was determined to take advantage of the earliest possible opportunity in obtaining a general revision of the geology of the entire province. No maps existed of any accuracy or detail sufficient to enable the observations to be carefully recorded, and Mr. Wynne, who was placed in charge of the geological examination, and whose powers as a draughtsman fitted him especially for the task, was asked to combine into one general sketch map all such data as were available; and to add such additional features as he could during his geological investigation. The general sketch map of the province which accompanies this report has been the result, and reflects much credit on the ability and zeal with which his labours were carried out. It will be found to give a good general idea of the physical features of the country and of the general relations of the rock groups also.

But I would desire to guard against its being supposed to be a detailed geological map, so far as the sub-divisions of the various groups are concerned. To have attempted to construct, under the circumstances, a map of sufficient accuracy and detail to admit of these minor groups being shown would not only have been next to impossible from the absence of sufficient data and triangulation-points for reference, but it would have involved an amount of time which could not have been

given to such work without almost entirely stopping the progress of the geological investigation.

Such details must be reserved for such time as the large scale map of the province prepared by the regular survey establishment be available. With the aid of this, and with the knowledge already acquired as to the distribution of fossils from the very extensive collections made by Mr. Wynne and Mr. Fedden during their examination of Kutch, it will be possible to map out in ample detail the various groups of the jurassic rocks represented in the province.

Towards this result great progress has already been made. The whole of the important group of fossils, the *Ammonitidæ*, has been carefully examined by Dr. W. Waagen, and a brief abstract of his results given in the Records of the Geological Survey of India (1871, p. 89). And more recently Dr. Stoliczka has examined the beds *in situ*, and fully satisfied himself that it will be easy to map out several of the groups and zones with as much accuracy as in parts of Europe. The full details will be given in a future part of these Memoirs.

I regret that some terms were allowed to creep into the report without notice until it was too late to alter them, which without explanation may possibly lead to erroneous conceptions. The terms upper and lower jurassic groups were intended to be of purely local application, and to apply solely to physical position; they have no reference whatever to the divisions of the great jurassic series, known as 'upper' and 'lower' jurassic in Europe and elsewhere, and it is requested that in reading the following pages they may be understood solely as intended to convey the idea of the existence of two great groups of beds belonging to the same general series, one of which was physically over the other.

No systematic attempt has been made to reduce the orthography of the names of places to any fixed system. We could not get the aid

of any one acquainted with the language of Kutch, and preferred, therefore, adopting the spelling already common to introducing new forms which, in all probability, would have been as erroneous, if not more so.

To Captain W. Murray, who was in charge of the lithographic department of the Surveyor General's Office, we are very deeply indebted for the great interest which he took in the preparation of the map, and for the time and trouble he personally devoted to it. It was the first work of the kind executed, in colours, of any extent, which they had undertaken in their Office, and the very satisfactory result is owing chiefly to Captain Murray's untiring interest in the work, supported, as he was throughout, by Colonel Thuillier, to whom on this, as on every other occasion in which we have sought his aid, we are under many obligations.

T. OLDHAM.

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PRELIMINARY REMARKS.—The regular operations of the Geological Survey were extended into Kutch (or Cutch) towards the end of the year 1867, a hasty reconnoissance having been previously made by Mr. W. T. Blanford in 1863, the results of which appeared among the Memoirs of the Survey (Vol. VI).

The only map of the province available for the purposes of the Survey was that compiled by Sir Alexander (then Lieutenant) Burnes, Deputy Assistant Quarter Master General, in the years 1825, 1826, 1827 and 1828, on a scale of four miles to an inch.

With a revised edition of this, bearing date 1854, work was commenced at the eastern side of the State, that being the least known portion of the district, and a locality where it was hoped that the observations to be made, together with those on a more central portion recorded by Mr. Blanford, would enable a correct conclusion to be formed regarding the hitherto doubtful relations between the *terrestrial* and *marine* fossiliferous beds, long known to occur more or less nearly associated in this district, while the terrestrial beds contained forms eminently characteristic of formations widely distributed in other parts of India.

It was shortly found that the inaccuracy of the map greatly deprived it of value as a means of expressing the facts noted, and steps were taken to correct it, as the work progressed, by the fixed points of the Great Trigonometrical Survey. A tracing of these was, however, only obtained towards the close of the first season as the party was returning to station at Bhooj. As on further acquaintance the map did not improve, that which is attached to this memoir has been carefully compiled, and the places fixed over all the central and western parts of the district by prismatic compass bearings, upon the basis furnished by the Trigonometrical Survey points, with such aid as could be obtained from Sir A. Burnes' map, different copies and editions of which vary so much from each other and from the ground, that it can hardly be expected several errors do not still remain, particularly as the means of correction, and the time which could be devoted to them, were limited.

As usual, the hills and rivers were the most misrepresented: the former have received a large amount of attention, and it became necessary to introduce many alterations of the latter also. With regard to the spelling of the names the usual difficulty has been found. No settled authority exists, and in different maps and publications much difference prevails. The language of the country is a *patois* or corruption of Gujrathi, in which some further complications besides the use of the interchangeable letters occur.

Use has been made of a list supplied by the kindness of the Political Agent, and in other cases it has been attempted to convey the sounds by the ordinary values of those of the English alphabet, and without the addition of unnecessary letters, to give as nearly as possible the native pronunciation. In some cases, however, the latter with contraction amounts to an entirely different name; for instance, that of the principal port, Mandavee, is often vulgarly spoken '*Mudde.*'

Frequent efforts have been made to ascertain by aneroid measurement the elevations of the most conspicuous hills; but so much variation has

been found in attempting to refer the observations to one base line that trustworthy results could not be obtained, and these observations can only be said to show approximately the altitudes above the adjacent low country.

Although a large collection of fossils has been made, the greatest part of which was furnished by the marine jurassic and tertiary rocks, those from the former gave little help, in the field, towards sub-division of the undoubtedly marine beds of that formation into zones of later or earlier age; while the examination of those obtained from the tertiary rocks not having been completed, the sub-divisions now indicated are mainly based upon petrological evidence, and upon such facts as the scarcity or abundance of fossils or the prevalence of well marked forms.

At the commencement of the examination of Kutch, attention was directed to two principal points,—the importance of discovering the true relations of the terrestrial plant-bearing to the marine fossiliferous beds of the jurassic rocks; and, the investigation of an unconformity supposed to separate the tertiary formation of Western India into two distinct groups.

With regard to the former of these, the results have established conformity of the whole of the jurassic strata and shown that while intercalation of the terrestrial and marine forms takes place to a small extent, by far the larger number of marine organisms occurs in the lower or older beds seen, while the characteristic 'Rajmahal' flora is largely, but locally developed in certain beds distributed through the upper portion of this great formation.

As to the supposed unconformity in the tertiary rocks, this has not been quite so satisfactorily ascertained. The fossiliferous beds seem, notwithstanding great irregularity of deposition and intermixture of textures, to form parts of a whole, but at the top of this series some very recent-looking rocks with obscure and variable relations to those below supervene, with apparent unconformity between them and the sub-recent coast deposits. Both of these points will be more fully treated further on.

The region most affected by the great earthquake of 1819, lying at a distance beyond the limits of the tract to be geologically examined, and surrounded as it is by difficulties of access, offered little to reward inspection, still with a view to ascertain something of its present condition, a short visit was made to the centre of the depressed area and the existing state of things noted. The interesting question of the Runn of Kutch being now slowly elevated has been considered, but owing to the want of protracted observations, the impossibility of forming any positive conclusion has only been arrived at.

Owing to the deserted nature of the country at the extreme west of the province in consequence of a long succession of dry seasons, it was only found practicable, and that with difficulty, to examine the outer margin of the broad hilly tract of stratified trap south of Lukput.

Within this tract the jurassic rocks may be exposed in some of the valleys by erosion, or outliers of the sub-nummulitic group may occur. Some conglomerate is stated by Lieutenant Merewether* to have been observed at the village of Sanundrow, but as this might only have been a river deposit, there was not sufficient evidence for an inlier to be marked upon the map.

The southern side of the province embracing the tertiary ground as far as Lukput, the Kalinjur hills in Nuggur Parkur, and the Island of Chorar, have been examined by Mr. Fedden, the remainder by myself, and this report has been compiled mainly from the field notes, with information supplied by Mr. Fedden regarding his portion of the work.

It must not be omitted to state that topographical and other valuable information upon several points has been obligingly furnished by Major (since Colonel) A. Y. Shortt, for many years Political Agent in Kutch.

A. B. Wynne.

* See appendix.

CHAPTER I.—GENERAL REMARKS AND PREVIOUS NOTICES.

General description.

The province of Kutch lies on the northern part of the West Coast of India, between the twenty-second and twenty-fourth parallels of north latitude and sixty-eighth and seventy-second of east longitude, being crossed by the parallel of the tropic of Cancer about 14 miles north of the capital, Bhooj. It is longer than wide, extending east and west for 160 miles, and from north to south it has a width of 50 miles at its widest part.

Four considerable detached portions forming a chain of hilly islands in the Grand Runn lie northward of the main tract. The most eastward of these, Chorar, does not, however, come within the political limits of Kutch.

The province has an area, including its detached islands, of 6,608 square miles, while the Runn is estimated to contain about 10,000, inclusive of the Bunnee, a low-lying tract scarcely distinguishable from the Runn except by some coarse vegetation which exists upon it.

The entire province and its outlying portions are isolated; from the sandy deserts of Sind to the north by the broad salt Runn, and from Gujrat on the east by narrower portions of the same; from Kattiwar on the south-east by the lesser Runn and the Gulf of Kutch, while its south-western shore is washed by the Arabian Sea.

The province belongs to His Highness the Rao of Kutch, by whom it is governed under British protection.*

Monsoon.

It lies almost beyond the regions of the south-west monsoon, so far as rain is concerned, though the winds are strongly felt, indeed calm weather rarely occurs.

* For general information regarding the history, &c., of the province, see a series of Selections from the Records of the Bombay Government, No. XV, edited by R. Hughes Thomas, Assistant Secretary, Political Department, printed for Government at the Bombay Education Society's Press, 1855.

Harsh east and north winds prevail in the cold weather followed by strong south-westerly gales and steady winds, the air being frequently loaded with dust. Dust-storms are common at certain seasons, and rain when it does come generally reaches Kutch from directions opposite to that of the prevailing winds, in the form of squalls from the north-north-west round by north and east, to south: to which fact attention was first called by Colonel A. Y. Shortt, Political Agent in Kutch, who afforded much valuable aid during the examination of the country.

Although heavy monsoon rains visit the western shores and side of India far to the north of Ahmadabad in Gujrat, they seem to pass over the southern parts of Sind and Kattiwar; the variable, partial, and scanty supplies received by the woodless lands of Kutch being represented by an annual fall of 14·30 inches, as the average of the 21 years preceding 1869, at Bhooj, the maximum registered being 34·88 inches in 1862, and the minimum 1·10 in 1848.*

PREVIOUS NOTICES.

It is usual to refer to previous publications regarding the geology of the districts being reported upon.†

Besides the comprehensive paper by Colonel (then Captain) Grant on the Geology of Kutch, assisted, as to fossils, by Morris and Sowerby, read at the Geological Society of London, much earlier papers, describing the great earthquake of 1819, and its results, by Captain MacMurdo‡ and Sir Alexander Burnes, have appeared elsewhere. Other earthquakes in 1844 and 1845 were subsequently described by General Sir G. LeGrand Jacob, and in a letter to Captain Nelson, R. E., communicated by the President to the above Society.

* From the register at the Residency kindly furnished by Colonel Shortt, Political Agent. An even lower minimum has been recorded.

† To avoid repetition the references to all papers and other publications known relating to the Geology of Kutch have been collected to form an appendix to this report. Some of these, however, have not been available for reference.

‡ Whose tomb is situated at the eastern margin of Wagir.

Sir Charles Lyell, in his "Principles of Geology," has an interesting section descriptive of the great earthquake, and its results, referring to the above accounts.

Allusions to the Geology of Kutch occur in Dr. Carter's 'Summary of the Geology of India' in "Geological Papers on Western India," edited by that gentleman: a volume in which also is reprinted Colonel Grant's paper, and a short notice of some fossils (collected by Captain W. Smee) by Colonel Sykes, F. R. S., Colonel Grant's map, and plates of fossils to accompany both papers, being given in an atlas to the work.

Remarks on the Allah Bund and the drainage of the eastern part of Sind, form a paper by Captain Baker in the Transactions of the Bombay Geographical Society; and two other papers by Lieutenant Dodd, subsequently read at the same Society, are chiefly descriptive of the country.

Mr. Blanford's paper has been already mentioned; and the next reconnoissance connected with Geology appears to have been Lieutenant Merewether's journey through the western side of the province in search of large stone for the Kurrachee Breakwater.

An article in the 'Bombay Saturday Review' on the recent elevation of the Runn and Kattiwar was followed by communications to the Government of Bombay from the Superintendents of the Geological and Great Trigonometrical Surveys, Mr. William Sowerby, C. E., F. G. S., Captains Haig, R. E., G. T. S., La Touche,* LeGeyt Hebbert,* Watson, Lieutenant Lloyd, Colonel Keatinge, V. C., and Colonel Anderson.†

While it is beyond the intention of the present report to enter into detailed criticism of these various publications, some notice is due to the earliest and most important records connected with the geology of the province.

* These two officers fell in a recent attack upon the Wagirs of Kattiwar.

† Badaoni, the historian, says—'In 1585, the Ran of Kachh (Kutch) was distant from the ocean, in some places 10, in others 30, kos.'

MacMurdo.

Captain MacMurdo's account of the earthquake of 1819 is interesting, but some of its statements regarding clouds of dust seen to arise from the hill tops, the bursting forth of fire and smoke, and ejection of a fire ball, are sufficiently peculiar to excite doubt as to the accuracy of his informants, particularly as the precise localities are not referred to, and nothing like a recently active volcano has been found in the whole province. His description of the changes of level which succeeded the earthquake coincide with later observations by Sir A. Burnes.

Burnes.

The memoir by the latter officer "on the eastern branch of the Indus and the Runn of Kutch," published at the end of the third volume of his travels into Bokhara, and also by the Royal Asiatic Society of London, describes the country and its alterations with considerable detail from personal observation. The native traditions regarding the Runn are given, and also some posthumous notes by Captain MacMurdo agreeing with the views of the author as to its having been an inland sea from which the water had receded; and the memoir concludes with a note on Sindree village and neighbourhood (since submerged) written by Captain R. M. Grindlay in the year 1808. A view of the fort of Sindree from a sketch by that officer accompanies the memoir. This view was afterwards copied in Lyell's Principles of Geology.

Lyell.

The notice of the earthquake of Kutch and elevation of the Allah Bund in Sir C. Lyell's "Principles," chap. 28, 10th Edit., omits nothing of importance, and several particulars are stated in a foot note to have been obtained from personal communication with Sir A. Burnes. A small map of the district and adjacent countries and two views of the fort of Sindree are given, one of which is taken from that by Captain Grindlay.

Of the publications previously enumerated, Colonel Grant's is one of the most important, dealing as it does with the geology of the

whole province, and being accompanied by a map, plates, and list of fossils.

Grant.

The early date of its publication (1837) explains to some extent the fact that the author's opinions seem to have been disadvantageously influenced by views which, however orthodox then, have since been discarded with the progress of geological knowledge. Although the paper contains many correct observations, and the author generalised with accuracy when separating some of his rock groups, the officers of the Geological Survey have been compelled to arrive at conclusions very different from his, owing to the leading facts as to the stratification of the rocks and their position not having been perceived or sufficiently regarded, and, perhaps upon the strength of this having been an earthquake region, more than was necessary being attributed by him to the direct recent action of volcanic force. No useful end would be served by particularising the various points of disagreement, these frequently resulting from the author's tendency to see in the weather-wasted condition of the ground evidence that it was 'shattered' by volcanic agency; while on the whole the paper, though often likely to mislead, calls attention to most of the prominent facts.

Carter.

The allusions in Dr. Carter's 'Summary of the Geology of India' to that of Kutch are slight, and sometimes inaccurate; certain rocks having been apparently classed in his list on the imperfect evidence of inadequate description.

Blanford.

Mr. Blanford's rapid traverses of the country from south to north and back enabled him to record the first satisfactory views of its geological structure, but did not afford him sufficient evidence to decide positively whether the *Zamia*-bearing beds were or were not intercalated with the marine series, though he thought it probable that they were. His shrewd suspicion concerning the existence of a fault along the north base of the Charwar hills has been amply proved to be correct.

Merewether.

Lieutenant Merewether's report to the Superintendent of Harbour Works, Kurrachee, mentions the kind of stone to be found in several places scattered over the west side of the district, but does not enter into geological details.

Bombay Saturday Review.

The article in the 'Bombay Saturday Review' treats of elevation and depression of the land, asserting rather strongly that "there is proof positive" that the Runn was within the historic period entirely beneath the sea, and that it is now certain it is gradually sinking; depending for corroboration of its being an "upheaved sea bottom" upon a quotation from a report to Government by Captain MacMurdo in 1815, and for that of its depression upon several acres belonging to the village of Bheemkutta on the borders of the Runn having been carried away by the sea during the two or three years preceding 1866.

It goes on to state that the flooding of the Runn by the sea is undoubtedly caused by volcanic action now depressing as it once raised it, but advances nothing in proof of this, beyond the statement that volcanic shocks in the Runn have been recorded by General Sir G. LeGrand Jacob. By a somewhat bold theory, the 'evolution' of Kattiwar, Kutch and the Runn is attributed to the accumulation of the deposits of the Nerbudda, Taptee, Saubermuttee and Indus, by ocean currents, assisted by volcanic action of elevation; and the calculation of the Venerable Archdeacon Pratt, that the attraction of the Himalayas raises the level of the ocean along the western coast of India gradually up to 1,000 feet* on the coast of Sind, is adduced to show that slight oscillations in the Himalayas and Hindoo Koosh Mountains would cause the Runn to become again an inlet of the sea.

* 5014·57 feet is the exact calculation (Proc. Roy. Soc., Lond., 1857). But Archdeacon Pratt has subsequently pointed out that he had only proceeded on an *assumed* density for the Himalayas and subjacent mass; whereas the density as determined by experiment would so modify the result as to render the effect on the sea-level almost imperceptible.

This article was followed by the extensive correspondence referred to in the appendix, in which the principal portions connected with the recent geological changes in Kutch are—a memorandum by the Superintendent of the Geological Survey, pointing out the importance of and distinction between the various actions mentioned in the article and making suggestions as to the methods of ascertaining whether the land on this part of the Indian Coast was rising or sinking—together with the memorandum on the subject communicated to the Bombay Geographical Society by Mr. Sowerby (with a supplement), arguing that the land has not been depressed, and attributing the changes along the coast to the oscillation of the tidal wave!

Correspondence.

The letters of Captains LaTouche, LeGeyt Hebbert and Watson give the results of their enquiries made in Kattiwar at the desire of Government; Captain Hebbert having seen no reason to believe that the Runn was undergoing gradual depression, while Captain Watson arrives at an opposite conclusion.

From the correspondence it also appears that Captain Haig was fully instructed by the Superintendent of the Great Trigonometrical Survey as to instituting a series of observations to determine the facts, but the results are still unknown.

In Mr. G. Poulett Scrope's valuable work on Volcanos at page 404, the erroneous statement of the existence in Kutch of an 'extinct volcanic mountain with an irregular crater' is repeated. Dhenodhur hill is the one usually miscalled an extinct recent volcano, but this does not occur, as he states, in the Daura or Dora (*i. e.* white) range. Other indications of eruptions are said to occur in the vicinity, but are not further specified; and a reference is made to Lyell's "Principles." The author was probably misled with regard to these statements by Captain Grant's allusions to 'blown out ground' and other appearances attributed in error to direct recent volcanic action.

from the low country bordering the Runn, and Gandara 534 feet above the village of Lackapoor. The plains have various altitudes up to 300 or 400 feet.

Level of the Runn.

The level of the Runn has not been accurately determined; observations made upon it with aneroid barometers differed little from others at the coast. The readings could not be taken simultaneously, and the differences, being less than the daily range of the instruments, were too small to permit any reliable deduction to be made, or indeed to be at all accurately measured.

It can be at most but a few feet higher than the ordinary sea-level, its surface being slightly depressed along the northern side,—in the Sindree basin,—between Putchum and Kurreer and near Adeysur.

Colouring of the rocks.

There are few places in which the rocks exhibit more varied and vivid colouring than in this district—both rocks and ground covered by their atmospheric debris presenting all three primary colors and numerous varieties of their compounds. Owing to the oxides of iron, red and yellow prevail; but in some places these are mixed with pale lavender, blue and purple tints, and contrasted with intense black or the purest white; and when any vegetation adds some green, the brilliancy of the effect becomes very striking.

As a rule, the country has warm sienna tints, with red, purple or black rocks pretty nearly always close at hand; while the gray, purple or orange hills are often varied by patches of white strongly relieved against the adjacent sombre color of some mass of intrusive or overlying trap.

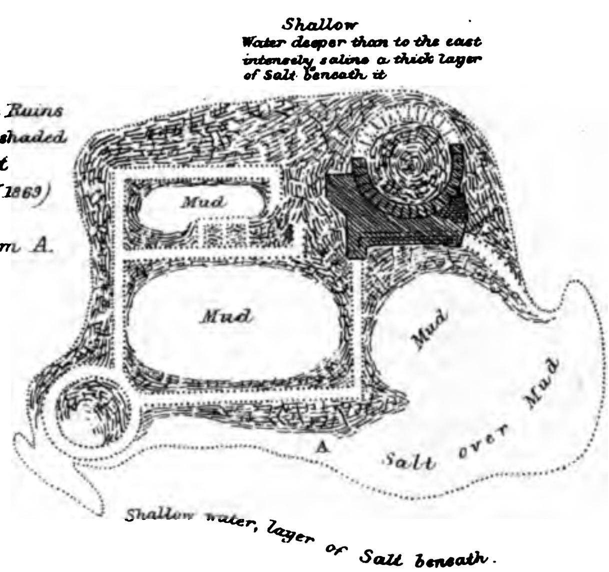
THE RUNN.

The singular expanse called the Runn, periodically covered with water, would seem to have been known to the ancients, and has been described more or less minutely by many writers, including MacMurdo, Burnes, Lyell and Grant.

LAST VESTIGE OF 'SINDREE' ON THE RUNN OF KUTCH
in 1869.. from the East.

Sketch plan of the Ruins of Sindree Fort. shaded part Standing but crambling away (1869)

View taken from A.



Where it embraces the Eastern or Wagir portion of Kutch, its breadth across the Grand and Lesser Runns is from 80 to 100 miles, and it has an indefinite length from Gujrat westwards towards the Indus of over 200 miles.

Length and width.

Its flat unbroken surface of dark silt, baked by the sun and blistered by saline incrustations, is varied only by the mirage, and great tracts of dazzlingly white salt or extensive but shallow flashes of concentrated brine; its intense silent desolation is oppressive, and save by chance a slowly passing *'qatár'* (caravan of camels) or some herd of wild asses even less likely to be seen,—there is nothing beyond a few bleached skeletons of cattle, salt dried fish, or remains of insects brought down by floods, to maintain a distant and dismal connection between it and life which it is utterly unfitted to support.* (See Plate I.)

Aspect.

At wide intervals, patches, a couple of feet above the general level, called *dhooi* or *beyt,* are covered with coarse rush-like grass. These appear to have been flat banks scarped by wave action or retained by vegetation, such as occur on low muddy coasts. The soil where very salt is called *'kara,'* where

Dhooi: Laana.

(1) * "The Runn or 'Rin' is a corruption of *Aranya** or the waste, nor can anything in nature be more dreary in the dry weather than this parched desert of salt and mud, the peculiar abode of the *Khur Gudda* or wild ass, whose love of solitude has been commemorated by an immortal pen. That this enormous depository of salt is of no recent formation we are informed by the Greek writers, whose notice it did not escape, and who have preserved in "*Erinos*" a nearer approximation to the original *Aranya* than exists in our Rin or Runn. Although mainly indebted to the Looni for its salt, whose bed and that of its feeders are covered with saline deposits, it is [was] also supplied by the overflowing of the Indus, to which grand stream it may be indebted for its share of water."—*Tod's Rajasthan,* Vol. II, p. 296.

(* Wiràna (from the Persian) in *Forbes' Hindustani Dictionary.* It has never been heard called 'Rin;' but the *u* of Runn partakes somewhat of the sound of *e* in wren. When written Rann, of course the *a* is to be considered the short *a*.)

(2) Although much of the Runn becomes quite dry and none of it marshy, in the ordinary acceptation of the term, Mr. Fedden observed lights, which he took to be *ignes falui,* when crossing at night from Béla to Nuggur Parkur in February 1868.

still salt but dark and bitter it is called '*kuller*,' and higher portions with some vegetation more seldom flooded are known by the name of Laana.

Bunnee.

The large tract called the Bunnee, occupying a wide space between the Putchum and Kutch Proper, has much of a 'dhooi' nature, rising gently a little higher than the remainder of the Runn, is scantily covered with coarse grass and *bábul* trees, and here and there inhabited by herdsmen, large herds of buffaloes and other cattle being sent here to graze.*

When floods are high upon the Runn the Bunnee is also covered, and those who are able resort to some more elevated spots, one of which, a narrow strip about a mile in length, was described as lying westward of Bindiara, and as being but rarely overflowed. No means are used to raise the habitations of these people above the ground, and when the inundations rise rapidly, much loss of human life and of cattle is stated occasionally to take place.

There are some shallow wells on the Bunnee at which the cattle are watered every second or third day; but when these are sunk to any depth, the water becomes too brackish for use. These wells are called '*naess*;' they do not appear to be so numerous as might be inferred from the use of the word 'abounding' on Burnes' map; and as resources they are supplemented by the construction of shallow tanks, which soon dry up. The western portion of the Bunnee would seem to be lower than at Bindiara, for the people stationed at Loona, to collect taxes upon the traffic from Sind, are obliged to leave that place in the rainy season.

The boundary between the Bunnee and the Runn, always indefinite, vanishes almost entirely south of the Putchum Isle, and the only apparent difference is that a narrow belt without trees intervenes.

* The inhabitants of the Bunnee live in clusters of beehive-shaped grass huts, and, according to Lieutenant Dodd, use no sleeping cots and light no lamp after dark, "both luxuries, it is said, having been forbidden by certain holy men."

In *Kutch Selections* (p. 6) it is stated that the whole of the Runn 'is frequently under water, when a passage across it is a work of great labor, and often of considerable danger; still, however, people continue to cross, though occasionally, if overtaken by a fall of rain, they are necessitated to remain there for a day or two, till the atmosphere clears and the direction in which to proceed can be ascertained.' Not unfrequently deaths occur from exposure, while to attempt to proceed without the means of guiding one's self would be, except with such people as have the organ of locality strongly developed, hopeless. Even in the dry season people occasionally lose their road and die from want of water, &c.

Water on the Runn.

The water which floods the Runn is partly brought down by the Bunnass and Loonee rivers, partly furnished by the small rivers of Kutch, while some is said to overflow it from the sea; this being raised in the Gulf of Kutch and the old mouth of the Koree river near Lukput by the prevalence of south-west winds.

Inspection of the coast at the western extremity of the province shows that this is to some extent the case. As in other gulfs, the tide rises higher the further it enters that of Kutch, and a combination of tidal wave and south-west wind would doubtless do much towards either flooding the Runn, or preventing the escape of the pent up waters which reach it from the land. In such a case the strong current which would flow, when the pressure of the wind became less or between tides, from the Runn, might effect a great deal of the deepening of the creeks and removal of the land noticed at the head of the gulf; but sufficient evidence on the point has not been collected to enable sound inferences to be drawn, nor is it so closely connected with the subject of this report as to render the discussion of imperfect data desirable.

Escape of the water from the Runn.

The depth of water and the time during which it rests upon the Runn necessarily vary with the season and the slight but hardly perceptible

undulations of its surface. Over much of it this depth does not exceed a few feet, being between Béla and Parkur (32 miles) about five feet for the five miles nearest Kutch, and for the remainder of the distance varying from six inches to three feet. Here a heavy fall of rain causes a current 'from the eastward, which has been known to carry people off their legs. Laden camels travel the pass on emergent occasions, but to prevent their slipping, their fore feet are tied, and the journey, one in the fair season, of a few hours' (by camel it is presumed) 'sometimes occupies two days.'* Between Kurreer and the Putchum the monsoon floods have a depth of about seven feet,* and the deepest portion is generally reported to be the channel between Adeysur and the island of Chorar.

Season of flood and depth.

The inundation generally lasts from July to the end of November or middle of December, while some low portions along the north side and in the Sindree basin never dry completely, or, like the narrow neck between Wagir and Chorar, do so as late in the season as the month of January.

The course of the water of the Bunnass river is shown upon some maps traversing the Lesser Runn to the head of the Gulf of Kutch, and that of the Loonee river crossing the Grand Runn towards the Koree estuary. In Western Kutch the inhabitants also assert that it is the Loonee water which floods that portion of the Runn, but Sir G. Le G. Jacob mentions a monsoon nullah not far from Gainda (or Gunyado) Beyt northwards from the Putchum, as sloping to the east, and he was informed that it emptied itself into the Runn near Adeysur 'and so round into the Gulf of Kutch.'†

Courses of the Bunnass and Loonee rivers.

This is the only nullah that has been heard of occurring in the Runn Proper. At no place has its surface been seen to undulate sufficiently for

* Lieutenant Dodd, who writes Kurreer '*Khuren*,' see reference in appendix.

† For reference see appendix.

one to be formed even a foot in depth, and the reputed direction of this indicates a fall in the ground quite contrary to that which it is generally supposed to possess.

Dera Beyt, a dozen miles or so to the north of where this nullah was observed, is said to have been joined to the mainland before the earthquake of 1819, but it is difficult to connect the subsidence supposed to have separated it with the occurrence of an east and west nullah of such a length.

Fall.

From what Sir G. Le G. Jacob says and the natives' descriptions, it is perhaps most likely that any slight fall which the general surface may have slopes from near Dera Beyt both to the east and west, the current recorded by Lieutenant Dodd being merely the first result of the Loonee freshets.

Caravan routes.

The caravans which cross the Runn from Sind take the direct route from Raoma-ka-Bazaar to Loona on the Bunnee, and thence into Kutch, or the more circuitous one by Balliaree, the Putchum and Bindiaro to Soomrasir, whichever dries up first; but a slight depth of water does not render the road impassable, camels being better able to proceed than when the surface is in a state of slippery mud. To avoid the blinding glare from the salt the passage is made at night, occupying rather more than the time from one evening to next morning; and when the track or beacons along the route cannot be seen, caravans are guided by the stars.

Salt.

The salt upon the Runn is generally from one to three inches in depth, but in the Sindree basin it was found beneath the water with a thickness of from three to four feet.* Its sources are various, being probably partly derived from the sea-water overspreading the Runn during the monsoon, partly from the

* By Mr. DaCosta of the Great Trigonometrical Survey: M.S. letter from Colonel Nasmyth, R. E., Superintendent at Poona.

large rivers to the east, and also largely from the smaller streams of Kutch which are nearly all strongly impregnated with salt derived from the rocks through which they pass. It does not form an important article of export as might have been expected, and its taste is usually rather bitter. Being partially distributed over the surface and always occurring in the beds of such pools or flashes as remain throughout the dry weather, it is evident that the presence of the salt is the natural result of repeated evaporation of saline water left in hollows by the retreating floods, its thickness of course indicating local absence of the deposition of silt.

Of the Runn Sir A. Burnes says:—"The whole tract may truly be said to be a '*terra hospitibus ferox*'; fresh water is never to be had anywhere but on islands, and there it is scarce; it has no herbage, and vegetable life is only discernible in the shape of a stunted tamarisk bush, which thrives by its suction of the rain water which falls near it. ...... The depression of the Runn below the surrounding country at once suggests the possibility of its being a dried up lake or sea', and 'nowhere is that singular phenomenon, the mirage or *saráb* of the desert, seen with greater advantage than in the Runn. The natives aptly term it smoke; the smallest shrubs at a distance assume the appearance of forests, and on a nearer approach, sometimes that of ships in full sail, at others that of breakers on a rock. In one instance I observed a cluster of bushes, which looked like a pier with tall-masted vessels lying close to it, and on approaching not a bank was near the shrubs to account for the deception. From the Runn the hills of Kutch appear more lofty, and to have merged into the clouds, their base being obscured by vapour. The wild ass is the only inhabitant of this desolate region; they roam about in flocks. ...... Their size does not much exceed that of the common ass, but at a short distance they sometimes appear as large as elephants. While the sun shines the whole surrounding space of Runn resembles a vast expanse of water, the appearance it commonly

assumes, and which is only to be distinguished from real water by those who are long habituated to such visionary illusions."*

Mirage.

The constantly prevailing mirage, called *'janjua'* in East Kutch, has not been seen on the Runn to quite so much advantage as above described, but its effect in magnifying objects and altering the shapes of hills has often been observed, the chief distortions being vertical: thus, when returning from Sindree, some men who followed next morning to search,—thinking the party lost,—appeared in the distance as tall as camels; and the hills of the Putchum and of Kutch often appeared divided by gaps, giving the impression of lofty tabular or domed mountains with mural sides, or horizontally separated from their bases as if raised into the air. The appearance of water with objects—when there are any in view—reflected upon it is of common occurrence.

The similarity which the Runn bears to a raised sea bottom has been often recorded. That it has been elevated from beneath the sea during recent geological time will appear from reasons to be given hereafter.

Animals on the Runn.

* The *Khar Gadha*, Onager, or wild ass, of the Runn is stated to frequent only that part of it in the neighbourhood of Kurreer. They are extremely wild, having never been seen by us within recognisable distance, but their tracks were occasionally observed. They are supposed to eat the coarse vegetation of the *dhoois*, and to visit the islands and margin of the upland at night in search of food and water.

According to the native account, as recorded by Lieutenant Dodd, "The ass is found in small flocks, composed of one male, several females, and the remaining animals devoid of the organs of generation. It is stated that on the males arriving to maturity they fight for the mastery, when the victor emasculates the vanquished, who follow afterward in his track."

Lieutenant Dodd says that Burnes, writing in or about the year 1830, mentioned lions, bears, tigers and wolves as to be found north of Bhooj, none except the latter being now visible; but that a solitary lion was shot on the Runn near Béla, supposed to have wandered from Kattiwar.

A few antelope, 'black buck,' were met with in 1868 on the Runn between Wagir and Béla; they are unknown in Kutch generally, and are likewise supposed to have come from Kattiwar.

CHAPTER III.—RELATIONS BETWEEN THE FORM OF THE GROUND AND ITS GEOLOGICAL STRUCTURE.

Owing to the absence of jungle and the rapidity with which the rocks of this country yield, each in its own peculiar manner, to the action of the atmosphere, the broad relations between the form of the ground and its structure are more obvious than usual.

Alternation of beds, and denudation.

The strong calcareous beds alternating with soft earthy shales and easily abraded saline sandstones of the northern side of the province, undulating over the ground —tilted at low angles inclining to the southward—or bent into long anticlinal curves, have determined all the principal forms of the surface under erosive influences slowly but continuously acting. Long gentle slopes coincide with the inclinations of the beds; and abrupt escarpments and declivities mark the places where the tendency of all stratified rocks to divide along planes, vertical to their stratification, has caused them to give way most to the wasting atmospheric agencies.

Almost every change in the bedding of the rocks is accompanied by alteration of the form of the ground; and where these relations are disturbed by the occurrence of intrusive igneous rocks, at least to any considerable extent, difference of texture has likewise produced variety of form.

Atmospheric agencies.

These results are so great and so well marked that it seems at first sight difficult to reconcile them with the existing state of things, the rain-fall of Kutch being very limited; but then the materials upon which it acts are fragile. Some of the earthy shales baked by the sun so as to give a sharp splintery fracture separate at once in water into unctuous mud; calcareous and trappean rocks are always strongly influenced by the weather; and the winds, which seldom rest in Kutch, no doubt play an important part in disintegrating the soft felspathic

ferruginous or saline, sandy and argillaceous beds, many specimens of which, solid when collected and in the shelter of a house, mouldered away to heaps of sand and powdery earth during one monsoon that gave a rain-fall of less than nine inches.

Other causes.

In some instances other causes anterior to the present results of atmospheric erosion have combined with it to produce the features. The great fault which runs along the northern face of the Charwar and Katrol range, placing the lower rocks which form the range at relatively much higher level than the newer ones occupying the plains to the north, has plainly influenced the configuration of the country, and it is quite possible that other east and west dislocations may have helped to produce a similar effect along the northern sides of the Kurreer and Béla chain, and likewise along portions of the sometimes strongly scarped hills which rise abruptly from the Runn, on the northern margin of the province.

Anticlinals.

Many of the hills of this marginal range have forms coinciding with the concentric curves given to the strata by a long anticlinal flexure, the axis of which undulates both vertically and horizontally, the chain being broken where the axis sinks and in places complicated by igneous intrusions.

Intrusions.

The latter have decided the forms of many isolated peaks and lesser hills of Kutch, in some instances producing minor ranges which traverse the country for considerable distances.

Sub-recent accumulation.

Traces are to be found in nearly all the glens of a sub-recent deposit, highly calcareous, more or less coherent, obliquely laminated, and irregularly bedded, such as no streams which now exist could suffice to form; and though the various inclinations of its stratification and different altitudes at which it rests are rather against the supposition of a general submergence with accompanying marine erosion, the deposit indicates a period when active

denudation was going on, and perhaps one when the features of the country differed somewhat from the present, and when the atmospheric agencies, under former conditions, were more effective.

In such rocks as have been mentioned the rivers cut deep channels, whose precipitous sides and heavily abraded forms convey a somewhat exaggerated impression of torrential action to which, under existing sources of water-supply, they can be but seldom subjected.*

Plains.

The plains of Kutch are of two kinds, one the ordinary coast-plain of Western India, the others traversing the interior of the country longitudinally on the general strike of the jurassic sandstones, but sending the streams which drain their surface in a direction generally at right angles to that of their extension. To the east of Bhooj, however, this peculiarity is less marked;

Plains formed over undulating beds.

and in the Wagir country the small rivers radiate from the centre to the shore. In these plains of the interior, the rocks frequently appear with gently undulating bedding, crags and scarps, of harder nature or steadier dip than usual, projecting above the surface.

In Wagir to the east the same relations as before described continue; a sharp anticlinal on its southern side, from the position of the beds,

* In a letter in *The Field* for June 12th, 1869, it is stated by Mr. P. S. Simmonds, that in the Runn of Kutch 240 inches of rain have fallen between June and September—*vide* his paper *Civil Engineers' and Architects' Journal, London*, November 1855. A particularly heavy rain-fall is sometimes spoken of, but one like that stated above must be beyond everything exceptional, to judge from the accompanying table extracted from the Kutch Residency register. It is probably a mistake for 24·0.

Year.	Inch. Cents.	Year.	Inch. Cents.	Year.	Inch. Cents.	Year.	Inch. Cents.
1848	0·10	1853	5·21	1858	13·45	1863	21·94
1849	8·79	1854	31·85	1859	10·63	1864	7·28
1850	21·60	1855	20·76¼	1860	1·60	1865	11·64
1851	21·51	1856	11·68	1861	8·33	1866	20·72
1852	19·32	1857	13·14	1862	34·88	1867	8·4
						1868	8·37

(1869 up to September 28th———23·74).

forming an irregularly branching ridge. Certain hard quartzose lines or 'ramps,' like 'blind lodes', are very numerous over the interior of the country, always projecting above the surface of the adjacent rocks, having better withstood the erosive agencies than these did.

Traps.

The belt of bedded traps which forms the range of hills nearest to the sea, follows the rules observed by the other strata, rising gradually with the southerly dip, in some places forming anticlinals which correspond with the outlines of the ground, and presenting several well marked scarps and short slopes on the out-crop of the beds. Alternations of softer and harder strata help to pronounce these forms, though the rapidity with which the rocks weather down sometimes tends to conceal the structure of the ground.

Outer foot of the trap hills.

Around the outer margin of these traps, is a band of variously colored soft rocks with some laterite and other harder beds. They are frequently gypseous, and occur sometimes as outlying patches and also in recesses of the traps. The ground formed by them is always peculiar, if from the number and brilliancy of its colours alone; and no other rocks in the district have forms showing more strongly the wasting power of the weather. Rocks of some solidity beneath are reduced upon the surface to powder, over which the foot falls as lightly as if one trod on ashes. This in some places seems to be the accumulated result of years of exposure to sun, dew and wind;. and from such ground a single smart shower must remove an enormous quantity of this disintegrated rock.

Tertiary plains.

The southern plains coincide with the tertiary rocks; these from the softness of their nature and horizontality of their undulating beds having doubtless favoured the production of this form of ground.

Wide depressions and somewhat elevated wold-like tracts also occur with much rolling ground at the western extension of these rocks, the same relations of hanging plane upon the 'dip' and more sudden slopes

upon the 'crop' declaring themselves wherever the situation is sufficiently high to have enabled the denuding agencies to remove their debris.

The nummulitic beds in the neighbourhood of Lukput form singularly barren ground; being in fact an undulating waste overspread by a white gravel composed of nummulites resulting from extensive decomposition of the calcareous rocks so thickly crowded with these fossils, that they have even forced themselves upon the attention of the natives, and obtained the name of *Lukput ka paisa* (money).

Runn.

Of the relations between the superficial condition of the Runn and the rocks which it conceals little can be said. Three different formations at least pass beneath it; and the basal portion of the jurassic, as well as the probable junction between these and the metamorphic rocks, is there lost to view. In fact there does not seem to be much more than a very general connection between the geological structure and this flat form of ground. Any varieties of rocks may form coasts continuing thence beneath the sea; and it may be presumed that nearly all sea bottoms if elevated would form plains of some kind.

The Runn an inland sea.

The strong tradition of the natives agrees with the conclusions of MacMurdo, Burnes, Grant, Blanford and others, that the Runn was once submerged. The former officer records the finding of an ancient boat, of a larger size than any now used in the Gulf of Kutch, beneath the mud of the Runn at a depth of 15 feet in the bank of a creek near the village of Wowannia on its Kattiwar coast; "there was no iron in the vessel, she was bound with cordage of coir." He also says that there was a tradition in the country that Khor, a village further east on the same shore, was a seaport town about the year 1765, and that perforated stones used as anchors by the natives have been found upon the shores of the Runn. From the 16th paragraph of Lieutenant Dodd's paper (referred to in appendix) it would appear that this date has reference to a period during which the Gulf of Kutch

may have extended further—one long subsequent to that when the Runn was navigable, as obscurely indicated by tradition to have "been at the beginning of the 14th century."

These traditions are, however, quite untrustworthy as to time, and the fact of the Runn having been formerly submerged, rests upon much better testimony, though the period at which it was permanently a sea may have been indefinitely remote.

According to Sir A. Burnes, the natives point out different positions said to have been harbours on the Runn at a time when the sea that covered it had the name of Kiln. Nerona, a village about 20 miles north-north-west of Bhooj (the capital), is one of these; Charee further west another; and "the people of the Putchum spoke of boats having been wrecked on the hills of the island, and said that there were considerable harbours near them called Dorut, Doh or Dohee and Phangwuro to the westward of Putchum." Bitaro, a small place on the road to Sind between Kutch and Allah Bund, is also said to have been a seaport, and he (Sir A. B.) "could point out several others."

On the Sind side of the Runn, Veego-Gud, the brick ruins of which are still visible, was said to have been the principal seaport; and Vingur and Balliaree were likewise said to have been ports. Again, Sir A. Burnes says—"numerous pieces of iron and ship nails were thrown up at Phangwuro at the time of the great earthquake, and similar things were subsequently found in the same neighbourhood when digging tanks." Lieutenant Dodd says that Veerawow or Veeravow in Parkur was "known to have been a port."

At one spot on the northern shore of the Putchum, some traces of this old sea have been recently found in a small patch of sub-recent littoral concrete full of marine shells. This was clearly *in situ* resting upon the local jurassic rocks at a height of nearly 20 feet above the Runn, but sloping towards it.

The 'Thur' or little desert, along the northern edge of the Runn, is described as a succession of sand hills or dunes such as fringe the sea-coast elsewhere, their only peculiarities being little basins of salt water in the hollows between them, and that they are in places covered with a miniature jungle of stunted shrubs.

To whatever causes the great plains of Sind and the coast plains of Western India are due, that of the Runn may also be ascribed. Its origin must be traced further back than the formation of the deltas of the Indus and other neighbouring rivers, because something in the nature of a plain or open ground was necessary to receive such deposits. This open ground was here more hilly than to the north in all probability, for the high islands which rise from the Runn are evidently but the modified summits of an older surface; and the silting-up of the sea-inlet which it formed was only the natural result of its land-locked capacity to retain the materials brought down by rivers. The Bunnee is a bank formed most probably by the discharge of the Kutch streams; and the slight elevation *en masse* which subjected the old shore-deposits to denudation has aided the tendency of the basin to retain transported sediment, which must accumulate yearly under present circumstances until the rivers that convey it find their way across the tract through channels traversing an alluvial plain. The surface of the Runn differs much from that beneath the neighbouring sea as shown by the Coast Survey Chart, on which are marked descents of 84 feet within less than a mile, besides various inequalities which do not exist upon the Runn. This may be accounted for by the protection from external currents formerly afforded by the land of Kutch.

Had the elevation above mentioned been but slightly greater, the present peculiarities of the Runn would have disappeared; and had it returned to its former level, it would have become again an inlet of the sea.

CHAPTER IV.—EARTHQUAKES.

Earliest records.

KUTCH has long been known as an earthquake region, the earliest recorded event of the kind being the disastrous and continued succession of shocks which commenced on the 16th of June 1819, and laid all its larger towns in ruins. An early account of the results was given by Captain MacMurdo, who was then engaged in a political mission to the provinces. From this, from Sir Alexander Burnes' Travels, from Sir Charles Lyell's description, and from that given by Lieutenant S. N. Raikes in 'Kutch Selections,'* we find that the first shock took place at nearly a quarter to 7 P. M., and lasted about 2 minutes,—'to keep the feet was not easy, and the motion of the surface was quite visible.' "Before 11 P. M. three more trifling shocks occurred, and on next day the earth was frequently in motion, attended by gusts of wind and a noise like that of wheeled carriages."

Effects of the earthquake.

For some time before 10 A. M. these symptoms intermitted for a few minutes, but at a quarter to ten o'clock a severe shock, which lasted about fifty seconds, brought down a number of shattered buildings. For some forty days, until the beginning of August, no day passed without shocks, generally slight and gradually dying out until the 20th of November, when the last distinct one was felt.

Discrepancy between the accounts.

Sir C. Lyell states that the shocks only occurred till the 20th of June, and that the movement was felt over an area having a radius of 1,000 miles from Bhooj, and extending to Khatmandoo, Calcutta and Pondicherry; also that the vibrations were felt in North-west India at a distance of 800 miles, after an interval of about 15 minutes after the earthquake at Bhooj. At Ahmadabad (about 200 miles east of Bhooj), the great

* For references, see appendix.

mosque, erected by Sultan Ahmad (1411–1443), nearly 400 years before, fell to the ground, attesting how long a period had elapsed since a shock of similar violence had visited that point.

First shock most violent: its results.

The first shock of the catastrophe seems to have been the most violent, "shaking every house from the Prince's Palace to the paupers' grass-hut to its centre: nor were the places of the dead exempt from the devastation produced by this mighty convulsion of nature." At Bhooj 7,000 houses, including the Rao's Palace, were destroyed, and 1,150 people buried in the ruins, and of the houses which escaped, one-third were shattered; hundreds of houses in Anjar, Mandavee and Lukput were hurled to the ground. All the fortified towns throughout the country were injured, and that which was reckoned the best fortress, at Tayra in the western maritime plain, was left with not a stone unturned.

Geographical changes and accompaniments.

With all this ruin the "face of nature" in the interior of Kutch was not greatly changed, according to MacMurdo. Large masses of rock and soil were detached from the precipices of the hills, and vast clouds of dust were seen to ascend from all their summits. 'Many gentlemen perceived smoke to ascend, and in some instances, fire was plainly seen bursting forth for a moment.' A respectable native assured him that considerable quantities of fire issued from a hill, and that a ball of large size was vomited into the air and fell to the ground still blazing. The hill next day was found rent and shattered, as if something had sunk, and the spot where the fire-ball was supposed to have fallen bore marks of fire in the scorched vegetation.

Certain of the results not capable of verification.

It is to be regretted that the sites of these occurrences are not given, so that the places could be examined. Dhenodhur hill, west-north-west from Bhooj, was said to have sent forth flames, and has thus received the name of a volcano, which it certainly is not; nor is there any spot in the whole

province, that has been either seen or heard of, which would from its recent volcanic appearance at all support belief in the assertions of fire and smoke having issued from the ground.

Rivers flooded.

The dry beds of the Kutch rivers are said to have been all filled to their banks for a short time, "the water having the color and taste of the soil, from which it would appear to have been forced. Many wells which had been fresh, became salt, and *vice versâ.*" This part of the account may have a better foundation than that about the bursting forth of fire; and it may be that the lower portions of the river courses only are meant. Very many of the Kutch rocks are retentive of water; and the undulating motion of the ground may have produced so much compression that this water was forced from places where it had lodged, somewhat in the same way as occurred recently at Cachar (*vide* Notes by T. Oldham, Esq., LL.D., Superintendent, Geol. Surv., on the earthquake of January 10th, 1869, at Cachar. Proc., Asiat. Soc., Bengal, April 1869).

Other changes and former condition of "Sayra."

But more lasting changes than these took place:—Formerly a considerable arm of the river Indus, called the Koree, traversing the delta found its way to the sea at the eastern extremity of Kutch, and its annual inundations watered the low ground north of Lukput, then called "Sayra" (? Sahrá), a fertile rice-producing country. Protracted feuds which long existed between the Governments of Sind and Kutch, led to the great battle of Jarra, fought upon the heights overlooking the Runn at that place, south-east of Lukput, and shortly afterwards (about the year 1764) to the construction of a bund across the Koree, in the Sind territory, by Ghulam Shah. The fresh water being thus stopped and led elsewhere, "Sayra" became a sandy desert; other bunds continued to be built, but the fresh water was not quite arrested until about the year 1802, when this was so effectually accomplished by one erected at Ali Bunder, that even the inundations of the

river failed to find a passage along its natural channel, which 'filled with mud and dried up above Sindree and shoaled at Lukput;' 'Sayra' becoming a part of the Runn, on which it formerly bordered.*

Depression.

Things remained in this state until the great earthquake which was accompanied by a sudden depression of a large portion of the Runn north of Lukput, and of smaller areas on its north and south sides near Dera Bét or Beyt, and in the vicinity of Nurrha.

Occurrences of year 1819.

In those days, Sindree was a station at which the Kutch Government levied customs; situated on the road to Sind, and on the left bank of what had been the Koree river about 25 or 30 miles north-north-east of Lukput. 'It had a brick fort 150 feet square, built for the protection of merchandize, with a small garrison, a few huts outside, and one well.' 'At sunset the shock was felt there, the fort was overwhelmed by an inundating torrent of water from the ocean, which spread on every side and in the course of a few hours converted the tract, before hard and dry, into an inland lake which extended for 16 miles on either side of Sindree.'

Flooding of the Bunnee.

The Runn and Bunnee between Kutch and the Putehum (also dry), were at the same time suddenly covered with a sheet of water, the extent of which east and west was unknown, but in width it was about six miles; its depth was upwards of two and a half feet, and after a few hours sunk to half that quantity. 'Horsemen who crossed this tract the day after the shock described a number of cones of sand' (from six to eight feet) 'elevated above the water, the summits of which were emitting air and water.' The inundation here was doubtless connected with that at Sindree fort, where it was of so much greater depth, that the houses within the walls filled with water and one only of its four towers remained stand-

* Even grass fodder for cattle ceased to be procurable at Lukput from this country about the year 1804-5 (Sir G. Le G. Jacob's paper).

ing; projecting sufficiently above the flood for the custom house officers to save their lives by ascending it. From this they were taken the following day in boats.

Changes in the Koree at Lukput.

The estuary of the Koree at Lukput was previously fordable, the water at ebb tide being about a foot and at flood not more than 6 feet deep; but after the earthquake the depth at the fort of Lukput became more than 18 feet at low water; and on sounding the channel Captain MacMurdo says it was found to have a depth of from 4 to 10 feet from Kutch to the Sind shore. In 1820, however, a ford was found here, while at the same place in 1826, Sir A. Burnes found a depth of 15 feet.

Uncertainty as to the soundings.

It is not clear that these measurements were all taken at the same place or very near it; a sharp bend occurs in the old river course at Lukput, some portions of which may have always been deep '*drohs*' or pools, while the rush of the sea water into the Sindree depression would be likely to deepen the passage through which it entered. The estuary is now again fordable near Lukput at low tide (1869).

Reputed elevation of the Allah Bund.

Simultaneously with or shortly after the submergence of Sindree, and about five and half miles to the north, the inhabitants 'saw a long elevated mound where the surface had previously been a low and level plain.' 'It extended east and west for a considerable distance and passed immediately across the channel of the Koree, separating as it were for ever the Phurraun' (Pooraun) (or the Narra and Goonee rivers, its upper waters) 'from the sea. The natives called this mound by the name of "Allah Bund," or mound of God, in allusion to its not having been a work of man but a dam thrown up by nature.' The height of the mound is given by Captain MacMurdo at 10 feet, by Lieutenant Raikes at 18, and is said to be pretty equal throughout. It has only the appearance of a mound as seen from the south side,

presenting no feature whatever to the north.* Its length is indefinite, being usually reckoned at fifty miles, or the east and west distance between the routes across the Runn from Loona (on the Bunnee) to Raoma-ka-bazaar on one side, and from Lukput in Kutch to Loonda and Garree on the other. The latter route is now disused in consequence of the dangerous state of the Runn, quicksands occurring on that side of the Sindree basin, and a more circuitous one has been adopted.

Reported elevation of Sindu.

The bed of the Koree at a place called by different writers Sindu or Sunda or Sundo, on the south side of the Sindree depression, is reported to have been raised for two or six miles by the earthquake of 1819.† The most definite information with regard to this spot is given by Sir G. Le G. Jacob, who, however, had some doubt as to his notes made respecting the locality. He says, "the earthquake of 1819 raised the ground, so as to leave the tide there waist high," and that it was subsequently raised still higher; but on the oldest copy of Sir A. Burnes' map procurable (dated 1828), the place affected by the tides is marked nearer to Lukput by eight miles.

The Indus cuts through the Allah Bund.

It is recorded ‡ that subsequently, in 1826, the Upper Indus burst its banks, overspread the desert, burst every artificial dam in the river, and forced its way by the old channel, cutting for itself a passage through the Allah Bund.

Sir Alexander Burnes visits the place, 1827.

To inspect this, Sir Alexander Burnes, in March 1827, proceeded from Lukput in a small flat-bottom boat by the river to the Allah Bund. At Lukput, and for twelve miles up stream, the river was 300 yards wide, and from two to three fathoms deep. At 'Sindu' or 'Sundo,' 'about four leagues distant from that town, the channel shoaled to 4 or 5 feet for two miles, but then regaining its depth, he entered on a vast inland lake that reached to the

* From description by an eye witness.

† Two miles according to Sir A. Burnes, six according to Colonel Grant's informant.

‡ By Sir Alexander Burnes. Authority cited.

horizon on all sides, amid which the remaining tower of Sindree stood like a rock in the ocean. At Sundo the water was brackish; at Sindree it was quite fresh.' Thence he proceeded to the Allah Bund, which he found to be composed of soft clay with shells elevated about 10 feet from the surface of the water, and cut through like a canal with vertical banks on either side. The channel was about 35 yards broad and three fathoms deep; and a body of the fresh water of the Indus rolled down it into the lake. Here he met several boats laden with ghee, which had descended from Wunga-Bazaar; and he further observes that 'there was water communication between Lukput and Omercote (in Sind) so late as May 1829.' Captain MacMurdo also mentions the water traffic of this period from Sind to Kutch; and Sir A. Burnes says that 'the earthquake had an immediate influence upon the channel of the river below the Allah Bund, which became navigable for boats of 100 tons from the sea to Lukput, which had never been the case since 1762.'

Sir A. Burnes' second visit in 1827.

In August 1827 * he again visited the locality, and found that great alterations had taken place: 'the river and lake were deeper in all places by 2 feet, the channel through the 'Allah Bund' was much widened, and the sheet of water was now entirely salt, but the stream passing the 'Allah Bund' was fresh, though greatly diminished in size.' This visit was made during the monsoon, and 'the south-westerly winds had blown the sea water in upon the fresh.'

1834.

When Colonel Grant visited Lukput in 1834, very little change had taken place since Sir Alexander Burnes' visit, except that the Sindians had repaired all the bunds across the river, and thus by preventing further supplies of fresh water, the 'lagoon' had assumed much the same appearance as before the freshes of 1828 [? 1826].

* Burnes' Travels, p. 318: in the year 1828 according to Captain Baker and Sir C. Lyell.

Ten years after the visits of Sir Alexander Burnes, at Sir C. Lyell's request, a native surveyor was sent to make a plan of 'Sindree' and the 'Allah Bund.' In the month of March he found the channel traversing the 'bund' to be 100 yards wide, without water, and encrusted with salt, and was told that it only contained 4 or 5 feet of water after rains. The sides or banks were nearly perpendicular, and 9 feet in height. The 'lagoon' had diminished both in area and depth, and part near the fort was dry land.

1838.

In 1844 the Allah Bund was visited by Captain (now General) Baker, of the Bengal Engineers. On the 11th of July, he found the 'mound,' where cut through by the Pooraun (or Koree), nearly four miles in width, but in other places it was said to vary from two to eight miles. Its greatest height was on the borders of the lake, above the level of which it rose 20½ feet. "From this elevation *it gradually slopes to the northward till it becomes undistinguishable from the plain.*" The bed of the Pooraun was 1 foot higher than the level of the lake; and 7 feet above that of a chain of pools of salt water in the same channel nearer Lallah Puttun Bund to the north (called Bundrejo Duryao), three koss from the Allah Bund.*

1844.

This is the only observer who mentions that the Allah Bund had any slope on the north side; and the section submitted with his report to the Sind Government shows a slope in that direction from the line of depression northwards, amounting to 19 feet in four miles.

Mr. DaCosta, of the Great Trigonometrical Survey, visited Sindree by boat from Lukput in the year 1856. He found water continuously the whole way, overlying salt in places 3 or 4 feet thick, and that hardly any traces of the ruins of the fort remained.†

Mr. DaCosta's visit in 1856.

* Sir G. Le Grand Jacob's Journal, see app.

† Communicated by Colonel Nasmyth, R. E., Great Trigonometrical Survey of India, Bombay.

In the month of May 1863 an intelligent person named Shaik Kasim, Surveyor to His Highness the present Rao of Kutch, was sent to explore the channel of the Koree in this vicinity. He likewise went by water from Lukput to the Allah Bund; northward of this the river was dry and without salt; but its bed was quite visible, 50 yards wide, with sloping banks from 10 to 15 feet in height. The ground to the north of the Allah Bund, and thence to the margin of the Runn near Raoma-ka-bazaar, he describes as more broken and rather more sandy than the Runn, of the kinds called '*kuller*' or '*laana*,' with clumps of coarse grass and a few bushes. It was, generally speaking, flat, with small undulations; had no perceptible slope to the north; was traversed by a few little water channels (seldom or never seen on the Runn Proper), which led to the old river bed for about a mile on each side of it, but outside this limit were supposed by him to approach the Runn by circuitous courses to the east and west. He thought the Allah Bund lower than the shore of the Runn near Raoma-ka-bazaar, where some sand hills formed the highest ground that he saw anywhere in the neighbourhood. Following the bed of the river through this ground, he found it deep and with better marked banks nearer to the above-named village; but at Lallah Puttun old bund it became again indistinct, and that bund on the upper side was obscured by silting up. The bund at Dost Ali Bunder northward of this was also silted up, but at Chaeta (? Chuttee Thur) Bund, still further north, there was a visible dam with fresh water on its upper side.

Shaik Kasim explores the country, 1863.

He estimates the distance from the Allah Bund to Raoma-ka-bazaar at seven miles (having paid camel hire for eight). This part of his journey occupied three hours, and he could go but slowly, the ground being in places muddy. As the result of his visit, he formed the opinion that the small quantity of water which could be obtained from Sind after supplying the irrigation there, would only be beneficial to the country northward of the Allah Bund, by restoring the cultivation once existing

about Veego-Gud, or rendering the *laana* west of that place cultivable; and that bringing the water to Sayra again would be of no use while the sea finds access to that part of the Runn during the monsoon.

Obscurity as to direction and velocity of wave.

From the accounts of the earthquake of 1819 little can be gathered as to the direction and velocity of its wave. The results were more marked in Kutch than elsewhere, which may be taken to indicate proximity to the line or centre of seismic disturbance; and this indication is strengthened by the circumstance that other earthquakes have occurred in the region. According to the data given by Sir C. Lyell, the vibration travelled northwards at a rate of about 53½ miles in a minute, and it would appear to have occurred almost simultaneously over Kutch.

Earthquake of 1844.

The next earthquake recorded is a series of shocks in 1844, mentioned by Sir G. Le G. Jacob in the paper already quoted. They are said to have further raised the bank at Sindu or Sundo, so that a foot and a half was 'the greatest depth of water ever found there.' 'Before they occurred, the usual tide went over the Sundo by about half a foot,' but in 1851 not at all. At spring tides, however, a boat drawing a foot and a half of water could with some labor be taken over the bank. 'These shocks also enlarged the breadth of the Allah Bund to the extent of three koss (six miles). The shocks are said to have lasted during a whole month, and were so threatening that while they lasted, the inhabitants (? of Lukput) feared to sleep in their houses.'*

Earthquake of 1845.

Some other severe shocks are stated to have occurred in the very next year, in an extract from a letter to Captain Nelson, R. E., communicated to the Geological Society of London by the President (*vide* appendix). The first shock of

* The next earthquake occurring so soon after this and being felt in the same locality, there may be a doubt as to whether both are not accounts of the same event.

this earthquake was felt on the 19th of June, 1845, at Lukput. It shook down part of the walls of the fort, and some lives were lost. At the same time the sea rolled up the Koree, overflowing the country westward to the Goongra river, twenty miles; northward to beyond Veyre, forty miles from the mouth of the Koree; and eastward to the Sindree Lake, which is stated to have become a salt marsh, but, on a map bearing date the same year, to be constantly under water to the depth of from 1 to 4 feet. From the 19th to the 25th, 66 shocks were counted, and much damage was done, nothing remaining of Kotree; on the Sind side of the river opposite to Lukput, except 'a few small buildings on a bit of rising ground,' of Veyre and other villages, only the remains of a few houses were to be seen; and Lak was totally submerged, nothing being above water but a flagstaff. At this time there were said to be generally two earthquakes in every year at Lukput.*

It was thought probable that a subsidence of the land accompanied this catastrophe, but there is nothing to show that the inundation was not caused by a great sea wave such as has frequently occurred in connexion with earthquakes.

Earthquake, 1864.

The only other and latest authentic record of an earthquake in this province is of one which occurred on the 30th of April 1864. It was chiefly felt in Wagir.—(From information supplied by Colonel Shortt, Political Agent, Kutch). It was also felt at Ahmadabad and Surat.

Earthquakes and volcanos proceeding from similar causes, a connexion may once have existed between the occurrence of the volcanic rocks of Kutch and the deep seated sources of its earthquake phenomena. The fact, however, that earthquakes rarely occur in the immediate vicinity of active eruptions would cast doubt upon the assertion that something of the

* None of the villages above named, except Kotree, are marked upon any map to which access can be had. The river Goongra may, perhaps, be that elsewhere called the Pinjaree or Seer; Veyre or Vaerr may be a village in Sind, 24 miles *west* of Lukput on the road to Mograbi.

kind attended the events of 1819; and it would indeed so far remove any immediate link between the presence of igneous rocks in the district and its earthquakes, that the latter would come to represent only the recurrence of widely separated periodic seismic disturbances, which might have been expected to take place beneath a long-quiescent region situated in one of the chief belts of volcanic action traversing the globe.

General conclusions as to subsidence.

The only one of these earthquakes which appears to have produced any material alteration in the features of the country within historic times was the first shock of 1819. The accounts given point plainly enough to the fact of some permanent depression of portions of the Runn to depths not exactly known, but in the case of 'Sindree' sufficient to submerge all but a small part of the highest tower of the fort. The original height of this fort is unrecorded, but such buildings in this country are generally carried up to about 16 feet.

The access of the sea water to the Sindree basin may have been assisted by a great sea wave resulting from the shock, and the undulation of the ground may probably have forced out water from the silts forming the bed of the Runn sufficient to considerably augment the quantity which sought the lowest level in the Sindree depression.

That the subsidence was not entirely confined to this place would appear from a note on Sir A. Burnes' map, that a *dhooi* or *beyt* ('Dera bét') near Balliaree on the north side of the Runn was joined to the mainland before the earthquake of 1819; and a depression of some low lands near Nurrha on its south shore is mentioned by Colonel Grant as having occurred at the same period.

Elevation of Allah Bund doubtful.

The elevation of the Allah Bund, however, is not so clearly established, though a general impression to this effect seems to have been felt by those who had the earliest and best opportunities of observing it. In all the accounts that have been given, its height seems to have been estimated from the

fluctuating level of the water in the Sindree Lake. Its length appears to correspond with that of this depression; but its width is said to vary from two to ten or sixteen miles, that is to say, the whole tract from the Sindree depression to the margin of the *laana* or Runn near Raoma-ka-bazaar has been looked upon as elevated, apparently because no abrupt slope such as exists to the south was observed on the north side of the Allah Bund.

Captain Baker, the only person who records the existence of any northerly slope, says that it is very gradual, and that the bottom of the dry channel crossing this bund or mound was 7 feet higher than some salt water pools, remaining in the same channel further up nearer to Raoma-ka-bazaar; but as he gives the depths of other parts of the channel as varying from 12 to 20 feet, this may not be extraordinary.

To decide this point of the real or apparent elevation of the Allah Bund and explain existing discrepancies, some further levelling would be necessary. Mere inspection of the ground, as described by Shaik Kasim, could add little or nothing to what is already known; and though the opinion of Sir A. Burnes and Captain Baker's detailed section should carry weight, the great fact of the Indus flood finding its way into the Sindree basin by following the old channel across a belt of elevation four, or sixteen, miles in breadth, instead of accumulating on the upper side of the obstruction and finding a new passage round one end, is worthy of consideration. This fact becomes intelligible only (in case of the mound having been really upheaved) on the supposition that a greater fall than the height of the mound existed between it and the Sind margin before the earthquake; and that after the general elevation of the intervening space, sufficient fall still remained to enable the stream to follow its old direction.

Taking the height of the mound at about 20 feet as given by Captain Baker, and allowing the distance from the Sind edge of the Runn to be so much as ten miles, this would give the old fall as something

more than 2 feet per mile or double that of the whole of the Indus from Attock to the sea.* If the height of the mound be supposed even half of that stated by Captain Baker, bringing it to the amount recorded by Lyell, the fall of 1 foot per mile would still seem too great for the old river to have had before the earthquake; and further, as the Koree or Pooraun was replenished by distributories of the Indus, its fall, according to Mr. Fergusson, may not have been more than six inches to the mile, while if the general flatness of the locality be considered, it was probably much less.

Had the former channel of the river possessed any considerable depth where the Allah Bund was formed, this ought to be deducted from the assumed elevation, but Burnes says, (p. 312), 'above Sindree it filled with mud and dried up.' From this it would appear hardly possible that after the presumed elevation of the Allah Bund, the country still retained sufficient slope to allow of the Indus flood of 1826 following the old channel southwards, and the fact of its being elevated to any considerable extent becomes somewhat doubtful.

The sectional profile supplied by Captain Baker shows the summit of the Allah Bund to be at the same level as the bank of the Goonee (a tributary to the Pooraun river) where the Mora Bund has been constructed thirty-seven miles to the northward of the former place. From this Mora Bund the bank is shown to decline regularly until within about four miles of the Sindree depression, when it commences to rise to the Allah Bund, gaining there a height of about 19 feet above its lowest point; so that if the channel of the river had become filled up, as Burnes states, before the earthquake, this profile would lead to the supposition that an obstruction 19 feet in height and four miles in width was insufficient to divert the river from its old channel,

* Mr. Fergusson's paper on recent changes in the delta of the Ganges, page 325, &c. Quarterly Journal, Geological Society, London, April 1st, 1863.

while there appears to have been nothing to prevent its turning aside over the lower ground to the east or west.

If the old channel was not entirely filled up, but a passage of some 6 or 8 feet deep remained open, this would still leave the obstruction so much higher than the river bank above that it seems hardly possible for the stream to have avoided seeking another course, unless the country to the east and west of the river is much higher than would appear likely from its situation.

From the amount of detail given in Captain Baker's profile section, it seems to have been very carefully constructed, but the difficulty still remains that, if correct, the country on each side of the Lower Pooraun cannot be flat; or if it be so, the stream must have preferred to ascend a rising ground, opening a new channel across it 20 feet deep and four miles long, rather than to seek the lowest level in the neighbourhood.

On the whole, while it is impossible to assert that some trifling elevation may not have taken place, it seems improbable that this amounted to 'throwing up a bund' 10, 15, 18, or 20½ feet in height.

Otherwise, if the maximum *subsidence* at Sindree took place along a somewhat irregular line corresponding to the place of the Allah Bund, and leaving the level of the ground to the northward but slightly, if at all, altered, then a bank or scarp, like that of the Allah Bund, might naturally result, its length being conterminous with that of the depression and its height marking the amount of this depression. Seen from Sindree, within the depressed area, rising beyond the widely spreading inundation, such a bank would assume the appearance of a low hill, and present a marked feature in a view which had previously been bounded by a distant line to all appearance as level as the horizon of the sea itself.

Tradition of the gradual silting up of the Indus.

Tradition far more ancient, though certainly less reliable, than the history of the events of 1819, has left an impression with the people of North-West Kutch that subsequently to the period when the Runn was a navigable inlet of the sea, having the ancient city of Veego-Gud upon its shore, another ancient maritime city flourished near Sindree, which was its port, or *bunder*, on the Pooraun or Koree river. In course of time the river shoaled so much by accumulation of silt that navigation was impeded, and the site of the city following the limits of deep water was changed to Sindee or Sindu in the Sayra country. Here again the channel became reduced in depth, and the people moved their city still further down the stream to Lukput, which had once a considerable trade, but is now almost deserted; its traffic having left it for the same cause and being now transferred to Kotésir and Narainsir on a deeper part of the estuary which was formerly the mouth of the Koree river. Mingled with this tradition are vague tales of the silting up of the Indus near Sukkur and the formation of the 'Alore Bund' near where the Nurrha or Pooraun distributory branched from that river in Sind; these changes having prevented the southward flow of the fresh water inundations which formerly fertilized the now ruined country of Sayra.

Visit to Sindree.

In connection with the objects of the Geological Survey an endeavour was made to reach the Sindree basin from Lukput in the middle of December 1868, but this was impracticable from want of water in the old river channel. Another attempt was made from Nurrha in the following month with the help of camels carrying supplies of wood and water.

The road lay from Nurrha north-east by Hajee Peer to Loona about ten miles, first over low '*kántá*' or bábul country and then over Runn and *laana*. Thence northwards four miles across the Bunnee to a group of grass huts and shallow wells *(naess)* on its margin, called Bitaro. From this, the last place at which fresh water could be obtained, the

track to Raoma-ka-bazaar was followed for twelve miles mostly over salt Runn and '*kuller.*' Branching from it to the left, at Jerruk Dhooi,* about four miles further on Ahmrai Dhooi was reached.

The whole of the Runn here was covered by a painfully glaring, strong crust of salt, as white as snow, thrown up into waves by the shrinking of the ground beneath, and in the neighbourhood of the *dhooi* thickly strewed with small salt and sun-dried fish, marsh or land shells, and portions of coleopterous insects.

From here the direction or distance of Sindree were but imperfectly known to the guides. At half past 12 o'clock, exchanging camels for two from the Bunnee said to be better accustomed to the mud, Ahmrai Dhooi was left behind to the south-east. For about two miles the salt was firm and even, though covered with heaps of sharp crystals; then entering upon the mud of the Sindree basin a somewhat devious course was pursued to avoid the worst places, the camels sinking to the knees at almost every step and the guides sounding the way in front with sticks. Riding became impracticable, and after labouring on till evening, at a rate of apparently nearly three miles an hour, the tower of Sindree at length rose to view above an horizon of mud and half dissolved salt, but was not reached till sunset.

Upon approaching the place it was found to be but a small spot, still surrounded by water; about 50 yards of ankle-deep, transparent brine with a sheet of white salt beneath, having to be crossed to reach the tower. This presented the appearance shown in the annexed sketch, (Plate II,) very little of the patch being excluded from the view on either side. The place of the old river course was occupied by brine, without banks, in which no current could be perceived; its width was estimated at about 250 yards, and it extended as far as could be seen to the northward and southward. All else around was level Runn, over

* A solitary hyena *(jerruk)* was seen here; what it could have found to live on except cattle dying on the road to Sind, is a mystery.

which to the south and south-east the Kutch hills as far as Dhenodhur could be seen; to the east the Putchum mountains; and to the north a thin dark line of rising ground marked the Allah Bund beyond which Veego-Gud and Raoma-ka-bazaar were said to lie. The distance from Ahmrai Dhooi was estimated at thirteen miles, which would agree pretty nearly with the position of the ruin as shown by crossbearings upon the Kutch hills; these, however, being very distant, the bearings could only roughly indicate the place.

The western half of the tower had crumbled and fallen; what remained of it, (see sketch plan, Plate II,) with small portions of adjacent walls, was little more than 10 feet above the mud, but how much had been buried in the silt could not be ascertained. The ruins had the appearance of being near the foundations; and some of the walls could be traced among fallen bricks, pieces of sandstone and flags—among which were lying, dead salt-dried fish, water snakes, and a few skeletons of birds.* The only living things on the spot were a dove, a hawk which had probably hunted it thither, and a few common house flies. The water on the west side of the ruins retained no appearance of a river. It was said to extend to the Allah Bund, visible northwards, and to the south nearly to Nurrha. Here, at all events, it cannot be deep, for two stray ponies seen on the opposite side at nightfall afterwards made their way across it, attracted by a small fire of driftwood which the guides had made; they did not appear to have found it necessary to swim over. No water mark could be observed upon the ruins.†

* Compare with the sketch and plan here given the sketch by Captain Grindlay taken in 1808, originally published in Burnes' Travels to Bokhara, 3rd vol., and subsequently copied full size in Lyell's Principles of Geology, or in a reduced woodcut in the 9th and 10th editions; and also with the sketch from a native drawing of the appearance of Sindree in 1838, in Lyell's Principles, Geology.

† Some sounds as of fish rising heard from the neighbouring water at night were said to have been caused by tortoises or turtle,—but were quite as likely to have been made by the ponies wandering at the water edge.

Thus it appears that the water of Sindree Lake is not permanent; and that but a little remains, somewhere near or over the old river channel, when the Runn dries up. The miles of mud which had to be crossed show, however, that after wet seasons or partial rains this Sindree depression would be flooded. It has doubtless become reduced in depth by 50 years' accumulation of silt, but this would appear to have been so evenly distributed as to still preserve a hollow where the river ran, and to have been partial or absent where the salt was found 3 feet thick. On the return to Ahmrai Dhooi next day (having been obliged to remain by the tower all night) a dangerous quagmire or quicksand was pointed out in the mud, similar to those at the west side of the basin; these perhaps representing such places as water was said to have issued from during the great earthquake.

CHAPTER V.—ROCK FORMATIONS.

The rock formations of Kutch have been sub-divided thus:—

FORMATIONS.	SUB-DIVISIONS.		PERIODS.
RECENT ...	Alluvium, blown sand and sub-recent deposits (m-n).	...	Pleistocene.
TERTIARY ...	Upper Tertiary	... F (l)	Probably both pleiocene and meiocene.
	(Unconformity.)		
	Argillaceous Group (Fossiliferous)...	E (k)	Meiocene or Upper Eocene.
	Arenaceous Group	... D (j)	Eocene.
	Nummulitic Group	... C (i)	
	Gypseous shales	... B (h)	
VOLCANIC TERTIARY	Sub-Nummulitic	... A (g)	
	Stratified Traps (e) and associated intertrappean beds	... (f)	
	Infra-Trappean Grits	... (d)	
	(Unconformity.)		
JURASSIC ...	Upper Jurassic Group	... (c)	Oolitic.
	Lower Jurassic Group (Dogger)	... (b)	
METAMORPHIC CRYSTALLINE ...	Syenite	... (a)	
TRAPPEAN ...	Intrusive Traps.		

SYENITE.

Taking these groups in the order of their antiquity, a basement for the whole, though at a distance, occurs in the crystalline rocks of Nuggur Parkur. Here the bold hills of Kalinjur are entirely composed of coarse red syenite or syenitic granite, having sometimes a foliated appearance on the weathered surfaces;—traversed by elvan and dioritic dykes and veins. As is the case in other places, it frequently exhibits large spheroidal forms. No schistose rocks were observed in its neighbourhood; but as these occur in

Kalinjur hills.

Kattiwar, it may not be too much to presume that metamorphic rocks extend far underneath the Runn and Kutch, supporting the whole of the secondary and newer formations.

JURASSIC.

This is the most largely developed formation in Kutch. Its characters are not, however, constant; considerable differences being found in the lateral extension of certain of the beds. It is not easy to give a general description of rocks so varied and yet so similar in their general aspect. Over large spaces the same varieties prevail to a degree which often renders it difficult to believe that they are not repeated; and the transition from one set of characteristics to another is so gradual, and accompanied by such alternate recurrence of slightly peculiar beds, commonly met with among one or the other, that the close determination of definite zones on purely petrological grounds is impossible.

Difficulty of a general description.

With all this similarity there is a broadly marked difference between the general character of the lower and the upper portions of the formation which has led to its division into two groups, these being understood to have no rigid line of demarcation between them.

LOWER JURASSIC.

Lower Jurassic.

These rocks are chiefly distinguished by the large quantity of argillaceous beds which they contain, and which, weathering down, give rusty orange tints to the (usually hilly) parts of the country formed of them. Among them are also to be found hard blue and gray quartzose layers, some strong cream-colored sandstones, blue, black and gray; sometimes gypseous shales, which wasting leave the ground covered with small red ferruginous nodules; certain buff orange and bluish or gray close earthy

limestones with sub-crystalline silicious varieties, thin bands of lumpy nodular conglomerate-like shale and layers of shelly limestone. One very peculiar rock is a coarse-grained, pebbly, glistening, golden oolite, the grains being coated with a thin film of lustrous brown hæmatite, that gives a resplendent appearance to the rock, which occasionally contains a few fossils. Ferruginous beds, except nodular ones, are more rare than higher up in the formation, though they sometimes occur, and some of them have a very peculiar, as it were, compressed angular concretionary form producing intricate concentric lines, the interspaces between which weathering away leave them in high relief. The component beds have a varying thickness, the shales of course being frequently finely laminated, and sometimes massed in bands, from 100 feet to much greater thicknesses, almost entirely made up of them.

Ferruginous beds.

Igneous rocks in many cases penetrate these lower Jurassics; and in some have a strongly contemporaneous aspect, but as the unmistakeably intrusive varieties occur with or near them, the appearance of inter-stratification may be frequently due to intrusion between the aqueous beds.

Igneous rocks.

From a few somewhat indefinite zones, rather than from the whole group generally, a large collection of marine fossils has been obtained, including *Trigonia, Astarte, Gryphæa, Terebratula, Ostrea, Cucullea,* and numbers of other bivalves with many *Ammonites*, some of which are of great size; some *Pleurotomaria, Chemnitzia,* and a few more univalves; remains of echinoderms, corals, fish teeth, reptilian bones, and quantities of *Belemnites*,—full lists of which are given with the detailed descriptions in the following pages.

Fossiliferous zones.

Many of the shales and more flaggy sandstones contain ill-preserved but numerous plant impressions of grass-like forms, with some of more woody nature and of considerable size; while fragments of silicified fossil timber are also to be met with.

Interstratification of terrestrial and marine fossil-bearing beds.

Prolonged but unavailing search was made over large portions of the ground occupied by these rocks for even a fragment of one of the *Palæozamiæ* known to occur in other parts of the formation; but not until the most westerly extension of this sub-group came under examination was anything of the kind observed. At one place there a few fragments of *Zamiæ* and ferns were found in a thick band of shales overlying, with the intervention of several feet of these shales, the marine fossil zone of the locality; while at some distance above, a thick bed of hard sandstone contained belemnites and obscure bivalve shells. The succession and intercalation being so far perfect, but the ground so disturbed by igneous intrusions, &c., that the separate beds could not be followed out for any great distance.

UPPER JURASSIC.

Transition beds.

Above the group so far described the sandstones become more brown in color, speckled with distinct white quartz grains, thick, with red ferruginous nodules, or more frequently thin and flaggy, rapidly alternating with shaly layers and partings. Red colors begin to predominate, and pale gray shales are found which contain but rarely a few *Zamiæ;* coarse grits and conglomerates, more rarely seen below, may be met with, and occasional thick bands of gray tough shale, full of plant fragments as usual, but seldom of recognisable form. These beds have often considerable thicknesss, preading over wide spaces, and the indefinite boundary between the lower and upper groups may be drawn almost anywhere through them.

Upper Jurassics.

Succeeding these are the more characteristic upper beds consisting of coarse white sandstones, some formed of large grains of white quartz loosely held together by a felspathic base, many gravelly and conglomeratic beds, interlaminations of coarser sandy and more argillaceous layers with crisp biscuit-like

ferruginous partings. The red color gives place to white, and the ferruginous beds are either rugged, full of annelid tubes, and root-like ramifications, or appear as strong, nearly black, grits speckled with quartz grains; strong beds of quartzite-like texture also occur. Oblique lamination is common, and some of the thick, warm, cream-colored beds are finely mottled with red, pink, yellow and white. Gray and white shales or mudstone bands still appear, and some of these, but by no means frequently, are crowded with matted impressions of *Zamiæ*, ferns, mosses, and other land plants without a fragment of any marine form.

Zamiæ.

In the lower part of these upper beds the vegetable remains have accumulated at one or two places to such an extent as to form thin seams of coal with brilliant facets, but much mixed with carbonaceous shale, and not of workable thickness.

Coal seams.

The bulk of the fossils found in this part of the formation are thus distinctly terrestrial, yet at the western side of the district intercalation again appears; a few beds containing marine shells having been met with, some of which, according to Dr. Stoliczka, possess peculiar interest from their relations to south African forms.

Interstratification of marine and terrestrial forms.

While there are but few varieties of the rocks of either sub-division that might not occasionally be found anywhere in the formation, the lower beds are generally more largely associated with argillaceous kinds, and have a yellower tint; the upper portion being marked by a predominance of white coarsely arenaceous and gravelly beds; and the largest assemblage of red and ferruginous strata lying generally, but not always, intermediate between the two. In all parts of the formation the rocks are frequently so saline as strongly to impregnate the water of the wells and streams.

General lithological distinction.

It has been said that the character of certain portions varies laterally; thus the lower jurassic rocks of the Putchum, which thickly sheet its lofty 'Kala' range, are hard silicious limestones and other calcareous beds—a group more largely developed here than in any other part of the district, becoming more shaly as the section descends. The same rocks extending into Kurreer and Béla to the east are still hard enough to carry on the same gentle sloping form of the hills upon the dip, but are, though very similar in color and appearance, less decidedly calcareous, and, while they contain numerous marine fossils, seem to underlie the Ammonite-bearing zone. In the Wagir tract, where from the structure of the country they would be expected to re-appear, the general aspect of the beds changes entirely; ferruginous and white sandstones predominate, associated with shales of grayer color and less rusty appearance than those which accompany the calcareous beds of the hills to the north: but one thick calcareous zone at the west side of this tract, containing many beautifully preserved bivalves, though differing as to the general assemblage of fossils, has a strong resemblance to the rocks of the island ranges; it underlies beds containing *Ammonites*, yet contains a few itself, and is underlaid by some beds in which *Belemnites* and plant fragments are almost the only fossils.

Lateral variation.

The strata of the Wagir tract undulate, with dips in all directions, so that the lowest beds ought to be found in the centre of it; but here the Kurreer and Béla beds do not appear, the rocks having much of the characteristic look of the upper and intermediate beds, while in places this appearance extends, with the northerly dip, to the north side of the tract, passing under the Runn; but where the rocks come up again in Béla, &c., on the opposite side of a synclinal curve, the change pointed out above becomes evident. Further west the part of Wagir opposite to Kurreer seems to form with that island a continuation of the synclinal, the shape of the hills and

Position of the Wagir rocks.

nature of the rocks on each side corresponding, though there is some difference in the sets of marine fossils which they contain.

It is possible that concealed faults may do much to obscure the relations of this ground; and there is room enough to imagine that the continuation of the Wagir rocks is concealed in the Runn and the low grounds of the islands, or that more complicated contortions are hidden there from view, and that the Putchum and Kurreer beds are much lower than anything seen in Wagir.

However this may be, the calcareous beds of West Wagir disappear over the rest of that tract in a manner most consonant with the supposition of their having thinned out or being replaced by other beds.

Changes in the Lower Jurassics, north of Kutch Proper.

Again, in the Lower Jurassics, along the north of Kutch Proper, the character of the rocks is subject to some change. At their eastern extension calcareous beds are comparatively scarce, and the shales are very thick in the centre of the hills. In the Juria hills, north-north-west of Bhooj, whitish calcareous beds or earthy limestones are abundant, and here the golden oolite appears in force. This again appears with calcareous beds of less thickness to the westward near the Keera hill; and these calcareous strata form the quaquaversal dome of Manjal hill south of Nurrha, where the oolite is represented by a few blotches only, the limestones being still traceable in the direction of Jarra beneath the cliffs. The whole of this ground furnishes about the same varieties of marine fossils; and the shales which are locally thick to the east also appear in greater force to the west than in the intermediate ground.

In Charwar and Katrol range.

In the Charwar and Katrol hill-tract of Lower Jurassics, however, none of these highly calcareous beds or limestones, nor the peculiar oolitic rock occur; and nothing more like the former than thin shelly calcareous layers has been met with,

showing a change to this extent within a distance of seventeen miles, the general character of the fossils remaining the same.

In no part of the Jurassics has it been found possible to trace out narrowly any one group of beds for a long distance. This may be in consequence of their lenticular accumulation in shallow water, evidence of which is afforded by the prevalence of oblique lamination. The transition from the lower part upwards is perfectly gradual and conformable, without a break; and there is nothing to suggest a change in the marine conditions except the occurrence, mainly in the upper, coarser and most cross-bedded portion, of layers locally crowded with fossil terrestrial plants; the beds themselves afford as good evidence of old land denudation as any of the streams of the district: their conglomerates point to shore deposits; and while it must be admitted that there is no *intermingling* of marine with the terrestrial organisms, it may still be possible that these latter were washed from the land into estuaries and littoral regions of the Jurassic period which may have been, from the prevalence of peculiar mineral salts or other reasons, unfitted to support a marine *fauna* except in a few favoured localities. This seems more likely than that a change took place from marine to fresh water conditions without leaving some palpable traces in the succession of the rocks to mark the alteration.

Conformity and conditions of deposition.

Igneous intrusions have repeatedly found their way through the Jurassic rocks. Their description belongs to another place, but their effect upon the rocks they traverse, ramifying sometimes with an intricacy that would defy expression, except upon a map of very large scale, may be mentioned here. The amount of alteration by the contact of these traps is various, gray shales are turned to black and red or dark olive, highly altered trappean-looking rock: sandstones generally become whiter and more silicious, resembling quartzite; while one peculiar white felspathic variety, in places where overlying trap may have been denuded or where the association with

Igneous intrusions.

dykes seems hardly adequate to the result, has become as completely and regularly columnar as any igneous rock might be; the columns having sometimes a length of some feet, but varying much in size. They occur both vertical to the bedding, and inclined at various angles. Portions of the Jurassic rocks not unfrequently are completely enveloped in the trap, or perched as cappings upon its hills; and in some places the alteration is so intense that the aqueous beds appear to have passed by a process of complete fusion into the trap; while in others the trap and sandstone are so intermingled that hand specimens may be found nearly all trap on one side and sandstone on the other, the passage being indefinite as if the base (probably felspathic) had been metamorphosed first and the grains afterwards; a few refractory quartz particles still lying in the trap at some distance from the nearest portion of the altered sandstone.

Thickness.

The visible portion of the formation has been estimated to reach a thickness of 6,300 feet, of which 3,000 may be allowed for the upper portion; but it should be remembered that neither the base nor the uppermost limit of the group is visible.

INFRA-TRAPPEAN GRITS.

These form a peculiar, soft, loosely granular, and obscurely stratified group of earthy and sandy rocks largely composed of trappean materials, which by weathering out give the stone a spongy aspect and assist in its disintegration. These beds rest unconformably upon the Jurassic rocks, and are frequently associated with the base of the stratified traps; but they also occur in separate patches over the country and sometimes at a considerable distance from them. They are clearly beneath the trap in some localities; in others they fill up hollows in the Jurassic beds, the planes of stratification not being conformable even to the surfaces of the hollows which they occupy.

The only fossils which the group contains are a few woody fragments or indefinite pieces of timber; and the intimate association of trappean blotches and larger lumps with sub-angular quartz grains in a rubbly calcareous matrix leads to the supposition that the group has an intimate connexion with the earlier volcanic flows, though it certainly differs much from anything that would be called ash. These rocks often weather of a greenish orange, and in some places the color becomes dark and the proportion of igneous materials largely increased.

Taking it to be partly derived from the waste of the coarse Jurassic sandstone and considering its other characteristics, the group has been looked upon as a local deposit of the lower portion of the stratified trap formation. Its thickness varies up to 1 or 200 feet, being generally less than the latter amount.

CHAPTER VI.—THE STRATIFIED TRAPS.

Distribution.

These rocks occupy a large portion of the district, forming all the hilly ground nearest to the sea and stretching in a broad belt from Anjar to the western side of the province. They also appear in outlying patches, some of which extend further east than Anjar, but they do not recur in the Wagir tract, nor have they been found on any of the islands in the Runn. The trap belt is broadest where most southerly, becoming irregularly indented and narrower as it trends to the north-west (the indentations sometimes breaking its connexion for short distances), but spreading over a large space where it terminates in the Gaira hills.

Unconformity.

The beds or flows rest, as a rule, upon the Jurassic rocks with complete unconformity, though in many cases this is but slightly apparent owing to the low southerly dip common to both formations.

Varieties.

The rocks consist of the usual gray, greenish olive and dark coloured doleritic, frequently amygdaloidal, or basaltic traps of the Deccan formation. They contain some similar zeolites coated with green-earth, the characteristic white agates, red boley layers, and beds of concretionary or columnar structure, the latter often magnetic; some flows are rendered porphyritic by glassy felspar crystals, some are greatly decomposed, and all are, as a group, identical with the Deccan traps, believed to be of very early tertiary age.

Intertrappean beds.

The lower flows are frequently thick, and zeolitic or sometimes ill-defined; and not far above the base some thick red sandstone is locally present: or earthy calcareous beds are interstratified which contain the well known *Physa Prinsepii* and a few other fossils. While sinuosity in the outline of the lower boundary might be expected from the unconformity which there

takes place, it will be obvious from inspection of the map that this unconformity has been assisted by a greater irregularity of the old surface in the western part of the district, or that the flows there were originally more local, being sometimes quite detached, or else that faults have so altered the positions of the rocks that these appearances have been induced. The difficulty of distinctly identifying most of the beds or flows causes much uncertainty as to which of these conditions have prevailed, or whether all three have not affected the present disposition of the traps. There is much in favor of each view: and unconformity once proved, the old Jurassic ground may have had any amount of unevenness. The traps seem, on the whole, to have been locally deposited, as they are not found anywhere in the far eastern or northern parts of Kutch, although a succeeding formation does occur which has not, at all events, been proved unconformable to them, and faults are too numerous in the district not to render it likely that they may have had their share in producing the irregularity of outline and sometimes the total absence of connexion between different areas of the trap formation.

Irregularity of the surface on which the traps were deposited.

Though the flows have a general dip to the southward at angles often under 5° and seldom more than 2° or 3,° they are thrown into an anticlinal fold in the Chitrana hills, dip to the west-south-west near their western termination not far from Lukput, and undulate over the broad space which they occupy in the Gaira hills south of that town, while to the east near Anjar they form a bold curve, their dips changing from south to east and more northerly directions.

Dip and contortions.

This formation being united both by lithological and petrological identity, and also by some circumstances of position, with the great Deccan accumulation (the largest trappean area known), its relations to the adjacent

Connexion between the features of the traps here and in other places.

rocks become not alone important features in the geology of Kutch, but have a connexion with that of a considerable portion of Western India. The upper boundary presents no such decided unconformity to the succeeding tertiary beds as has been recorded, with regard to the junction of the same groups, at a distance to the eastward, near Surat and along the foot of the Rajpipla hills, on evidence much less perfect so far as rock exposures are concerned.*

Thickness.

The thickness of the Kutch traps, about 2,500 feet, is perhaps less than one half of that which is attributed to those of the Deccan, and dykes, so numerous in places there, are rarely seen here, although the frequent intrusions in underlying Jurassic rocks show abundant evidence of volcanic activity, indicating doubtless many of the sources whence the materials of the overlying traps were derived. The fact that dykes are not a marked feature of the formation here does not prove their entire absence. Similarity of the rocks might often conceal them, and such as might be caused by filling in of fissures from fluid flows above would seldom occur if rapid accumulation and slow rates of cooling had united to prevent fissures being formed by the contraction of the lower masses. Instances exist in other portions of this great Deccan formation where dykes are equally rare.

Dykes.

Cones.

As elsewhere, no single instance of an old volcanic cone has been observed within these traps, nor any such local arrangement of the beds as would indicate the former existence of such among them.

Difference.

On the whole, the chief difference between this and other sub-aqueous volcanic regions is apparently the scarcity of stratified conchiferous beds of tuff or ash known to be the distributed material of volcanic cones. Mr. Blanford has called

* Mem., Geol. Surv. of India, Vol. VI.

attention to the frequent occurrence of scoriaceous volcanic ash, but this is certainly very different from the well stratified materials of some of the aqueous intertrappean beds.

Volcanic ash.

These beds of volcanic ash, so common in the formation, however, may represent the material that would have formed cones if the eruption of the traps had not been sub-aqueous, or subjected to conditions which prevented either their formation or preservation; and the occurrence of the ash in thick beds instead of thin laminæ may be merely the form of their distribution underneath water in contradistinction to that which they would have assumed from falling in showers through it, or from having been brought down by intermittent streams.

Absence of Tufa, &c.

The absence of the remains of old cones and littoral tufaceous rocks may indicate perhaps that the mass of the traps was accumulated at great depths, or that they found their way to the bottom of the sea through dyke-fissures or other vents than craters. Otherwise it seems extraordinary that some remnants of the cones and craters have not been discovered in position.

Vents in the sea and in Konkan.

It has been suggested (by whom is uncertain) that the sources of the traps were a line of volcanic vents once existing where the sea is now to the westward of their area; and a line of vents has also been said to occur parallel to, and beneath, the Western Ghâts in the Konkan (Kókan);* but from neither of these sources can be imagined sub-aërial flows reaching some 500 miles to the east; while better evidence for their origin is afforded by the numerous sources of igneous protrusion found within, or in the vicinity of, the traps or the country from which they may have been removed.

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* Remarks upon the basalt dykes of the mainland of India opposite to the Islands of Bombay and Salsette, by Geo. T. Clark, Esq., F. G. S., *Quarterly Journal, Geol. Soc.*, London, Vol. XXV, Pt. 2 (No. 98, p. 164).

In Mr. Clark's interesting descriptive paper, just referred to, allusion is made to 'particular vents' not connected with the basaltic dykes, as these pass them at tangents and do not radiate therefrom; unfortunately these vents, or what may have been taken for them, are not described fully, nor are their situations pointed out. The dykes themselves do not appear to have been traced to termination in any particular flows which might thus have been assumed to have issued from them. Their numerous occurrence in a north and south belt traversing the Konkan may perhaps have arisen from their occupying fissures connected with the disturbance which has given the low easterly and larger westerly inclination to the beds of trap, sloping from an axis coinciding, it may be nearly, with the line of development of these dykes.

Position in a great zone of volcanic action.

Elevation and depression.

The Deccan and Kutch volcanic region lies in the great volcanic zone extending from New Zealand through the Sunda Isles, India, Persia and Southern Europe on to Iceland, taking in the sites of submarine volcanos in the Bay of Bengal and the Mediterranean, and also several areas of elevation and depression. Its situation, therefore, taken together with the connexion that exists between volcanic action and changes of level may fairly warrant the supposition that this region has been both elevated and depressed perhaps many times. There is evidence of the geologically recent depression of the Maldive Islands off the Malabar Coast; and there are traces of recent elevation and depression further north on the Indian shore at Bombay.* Actions of the same nature may have taken place at an earlier period; and it may be worthy of consideration whether the vast quantity of igneous materials ejected, taken at 200,000 square miles by about a mile in thickness, would be unaccompanied by some depression to correspond with or occupy the vacant space.

* Mem., Geol. Surv., India, on the Island of Bombay, by A. B. Wynne, Vol. V.

Under the supposition that both elevation and depression, to the extent of submergence, accompanied the volcanic activity of the region, all its features can be explained: cones having been thrown up in shallow water or on land during submergence, it is conceivable that many of them would be swept away by wave action, and thus the earliest traces of the sources of the igneous materials might be destroyed. Subsequent eruptions in the sea may not have formed cones, and later still elevation might occur, or the accumulating flows at last raise themselves above water when lacustrine deposits could be formed.

Temperature.

The high temperature of the water and unsuitable nature of the land might have prevented the existence of organic life throughout most of the period; while the breadth and evenness of the slightly elevated tracts would tend to conceal the limits of those localities which may have been sub-aërial, subaqueous, or submarine, except where fossils could be found, there being nothing sufficiently marked in the general characters of the flows to distinguish one set of conditions from the other, any more than there is to show how far the eruptions of the period may have been strictly contemporaneous.*

Conclusion.

There being nothing impossible in the idea that these Kutch traps or lavas may have spread themselves out partly on land but mostly under water, the materials having risen through outlets possibly as numerous beneath the whole area as

* It would be interesting to compare with the Deccan traps the features of the smaller basaltic tracts of Scotland and the north of Ireland. The latter, with an area of 1,200 square miles and thickness of 900 feet, is similarly of supra-cretaceous position, has no volcanic cones, is composed of a variety of amygdaloidal and columnar layers with beds of ashy, ochreous or earthy nature interstratified. It has yielded fossils of tertiary age, and is stated by the late Professor Jukes "to have been probably of submarine formation." —(*Jukes' Manual of Geology*, p. 331.)

in the adjacent underlying rocks, it seems safer to adopt this view rather than the sub-aërial theory involving operations so different from those resulting in the terrestrial volcanic phenomena of the present period.

INTRUSIVE TRAPS.

Intrusions confined to jurassic area.

The very numerous trappean intrusions of Kutch are almost entirely confined to the jurassic area. Their general similarity and extensive distribution shows their source beneath the whole area to have been extensive; and their frequent identity with the overlying stratified trap, in numerous cases differing only in the absence of stratification, leaves little doubt, if any, that the superincumbent flows found their way to the surface through similar channels; many of these intrusions marking absolutely passages through which they rose.

Varieties.

They include nearly all varieties of doleritic, trachytic and basaltic traps, crystalline, compact, or porphyritic, seldom amygdaloidal, sometimes columnar, and frequently so friable and disposed to weather away that no clean fracture can be obtained. Some lavender or purple and red earthy lava dykes and pockets occur by themselves or associated with the other intrusions. From their resemblance to certain beds or flows overlying the rest of the stratified traps, they are supposed to have formed some of the latest eruptions.

Purple.

Larger intrusions.

The larger intrusive masses which will be found marked upon the map, forming considerable sized hill ranges, are all of a coarsely crystalline doleritic variety, which assumes under the influence of the weather the massive form and external appearance of iron-stained syenite. These intrusions penetrate the rocks in the most complex manner, some hills being a tangled net-work of dykes and intrusions embracing large masses of the associated

aqueous strata: sometimes portions of the latter are completety enveloped in the trap as already mentioned, or the latter has found its way in such quantity between the beds that considerable hills composed of it may be seen supporting caps of white silicious altered sandstone.

Other places occur where intrusions are so numerous, and so frequently intercalated with the beds, that appearances of the traps being contemporaneous are often presented in detail, alternations of the aqueous and igneous rocks taking place every few yards, and the aspect of the ground being indescribably confused.

Alterations.

The changes produced in the containing rocks by contact with the traps are sometimes extreme, whole beds sometimes appearing to have been altered *in situ* into rock having much more the splintery nature, dark color, and general aspect of the trap than that of their adjacent unaltered portions.

In most cases the difference of texture between the aqueous and igneous rocks has produced differences in the form of the ground; the latter standing out as hills, frequently conical or forming the summits of cones, parts of which are composed of the other rocks.

Dykes.

Dykes are numerous in some localities, but follow no definite arrangement as to direction, more frequently crossing the beds than following their strike. No dykes are known in the purely aqueous tertiary rocks of Kutch, but some doubtful cases of dykes of purple trap occur in the subnummulitic group.

CHAPTER VII.—SUB-NUMMULITIC, TERTIARY, AND ALLUVIUM.

Immediately overlying the stratified traps, and resting usually upon a crystalline concretionary amygdaloidal flow having often an irregular surface, and weathering of a greenish rusty color, a singularly mixed and varied band of rocks is found.

Position.

It occurs as a narrow belt all round the upper portion of the traps to the west, but has been seldom met with at their eastern termination about Buddrésir and Anjar, being there perhaps concealed by an unconformable group forming the upper member of the tertiary system. Near this it re-appears, continuing to the neighbourhood of Bucháo; and it is also found entirely beyond the limits of the trap area in the Wagir tract, and on the south and south-eastern sides of the larger islands in the Runn.

The rocks.

It consists of soft variegated pseudo-brecciated or concretionary unctuous aluminous rocks of pale purple colors mottled with white. Pure white varieties also occur, which soil the fingers, and sometimes contain disseminated grains of white quartz; and associated with these are strong red and mottled laterites in places veined with hæmatite, in others containing agates. Coarse sandstones largely composed of semi-transparent quartz grains occur irregularly with purple or brown bands of silicious and ferruginous rock resembling quartzite; and the group also contains red or brown gypseous and dark aluminous or white sandy shales full of leaf impressions, small resinous lumps, and carbonaceous layers; some of the dark beds being so bituminous as to burn readily at a candle; while from others alum is manufactured at Mhurr. The whole group forms a series beautifully varied both in texture and colour; white or red, delicate lavender, strong purple, and warm orange, tints prevailing.

Short of absolute intercalation this group presents many appearances of conformity to the traps, though its lowest beds are often so soft and semi-soluble that they hardly retain their forms sufficiently to show clean sections. These lowest beds are generally the white or variegated unctuous breccia, having sometimes a large concretionary structure, with which that of the underlying uppermost trap flow coalesces in a peculiar way, the spheroids of the brecciated soft bed having centres of the same nature as the trap below, surrounded by coatings each more nearly approaching the character of the containing rock, which has altogether a strongly volcanic appearance. No case of unconformity to the traps is known; mere regularity of succession would not of course establish the contrary, but the general arrangement of the band—surrounding, following, and overlying the highest of the traps,—indicates such conformity as might exist between the later (probably more intermittent) trap flows, and still newer volcanic eruptions associated with the deposits of a succeeding period.

Conformity to traps.

The most volcanic-looking beds have often, in hand specimens, a 'derivate' appearance, resembling chemically metamorphosed states of some 'ingenite,'* such as porphyritic dolerite, magnesian amphibole, or pyroxene; but the manner of their occurrence is that of normal amorphous ash, perhaps sub-aqueous lava, or possibly volcanic mud—that is to say, if chemical metamorphosis has taken place the whole body of the rocks has been equally altered, and there is nothing in their aspect to lead to the belief that excavation would disclose any more original rock within their mass. Some difference of conditions attending their production may be argued from the dissimilarity between them and the bulk of the stratified traps. That these conditions, however, were connected with their origin or state

Petrological appearance.

* Terms proposed by my friend and former colleague Mr. Kinahan, Geol. Sur., Ireland.

of eruption, may be inferred from the fact that some of them, so soft and tough as to be easily cut with a knife, are identical with specimens from dykes, or from *"gites de contact"* in intrusions, occurring either alone or associated with the ordinary igneous rocks intersecting the Jurassic beds of the interior of Kutch; these traps doubtless occupying channels through which some of the overlying flows found access to the surface.

Identity with lava of dykes.

The white beds of these rocks are often very similar in appearance to that which Mr. Blanford describes as laterite without the peroxide of iron near the Taptee, (Mem., Geol. Surv., India, Vol. VI, p. 210).

The volcanic looking varieties, both purple and lighter coloured, when dry fuse with some difficulty before the blow pipe into a black and white speckled glassy substance on the edges. But some small waxy, greenish white, steatitic-looking blotches in one variety (from a mass of intrusive trap at Ruttria) do not change colour, becoming but slightly vitrified or rounded on the edges, and yielding less readily to the blow pipe than their purple matrix, which decomposes quickly and has a saline taste.

The more evidently mechanically formed aqueous beds of this sub-nummulitic series, though intercalated with the others, prevail most in its upper part; but laterites of slightly differing varieties range through the series, sometimes forming the basal, sometimes the uppermost bed; while ferruginous bands of very lateritic aspect appear in the tertiary series at some distance above the whole group.

Laterites.

The laterites are earthy, compact or nodular and scoriaceous looking, sometimes so highly ferruginous as to become an iron ore (anhydrous peroxide), which in part furnished material for the iron manufacture, formerly carried on to some extent in Kutch. They vary somewhat in texture, but often

possess the well known brownish color and glazed surface of this rock. In many instances they are so nodular as to resemble conglomerate; and some of them overlying the white unctuous rock are blended with it as if by infiltration, large vertical stalactitic like masses close to each other passing from the laterite downwards into the lower rock, as seen in the accompanying sketch:—

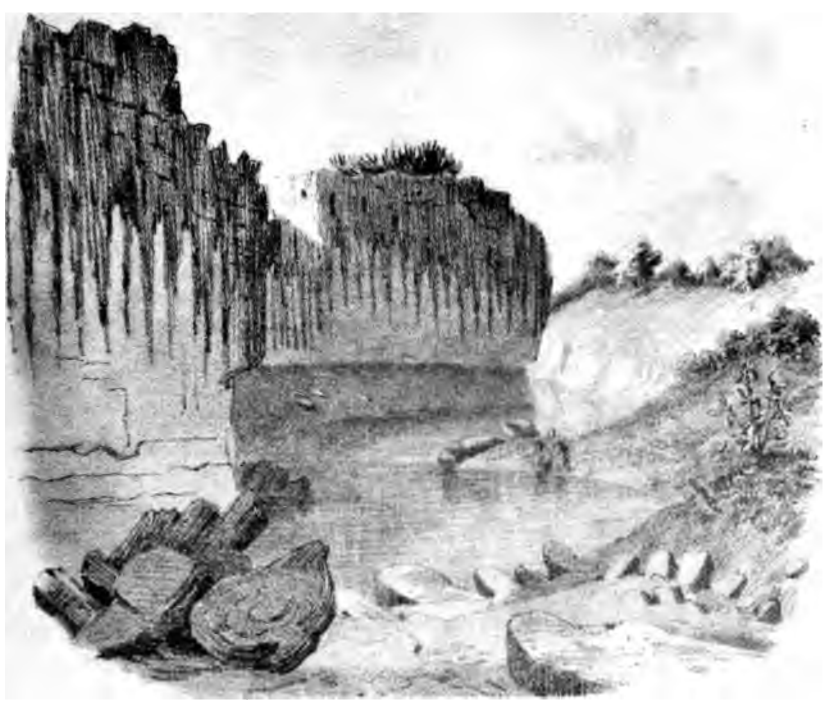

Fig. 1. View on the river at Chaper.

Laterites with agates.

In Eastern Kutch the laterites and white beds form nearly all that is seen of the group; and here they yield rapidly to atmospheric action, the ground occupied by them being so weathered into hillocks, resembling the waste-heaps of a foundry, that the rocks are often quite concealed. In other cases wide swelling plains are sheeted all over with a hardened laterite crust

formed of their debris; such ground is sometimes thickly covered with a coating of agates which have also been found embedded in the ferruginous lateritic rocks of the neighbourhood.

Varying sections.

The sections afforded by the sub-tertiary beds vary as might be expected at different places; sometimes the white beds are absent below, and the laterite rests upon the traps, the strong red color serving to distinguish it at a distance of several miles, for the lateritic and hæmatitic beds may be said to prevail wherever the group is found.

Dips.

Where the traps are present the dips of the sub-nummulitic group always coincide with their dip; in their absence the group generally slopes at low angles from the jurassic ground; but undulations, sharp dips, and anticlinal curves are also to be met with.

Thickness.

The thickness of the band varies also; it seldom exceeds 200 feet, and sometimes is not more than 20. In the northern and eastern parts of the district its thickness is often much greater than along the southern side of the stratified trap hills.

The relations between this and the overlying tertiary group are obscure, the junction or transition often taking place among soft gypseous or other shales; and indeed where these are largely developed, together with certain beds of dark ferruginous or coarse whitish grit, it becomes a matter of extreme difficulty, when the traps are absent, to separate the sub-nummulitic from the jurassic rocks below or the tertiary beds above; while the appearances of absolute conformity to the jurassic beds on which they rest in the north-east part of the district for some time induced the belief that they belonged to that formation.

The group is not, as a rule, fossiliferous, or rarely so; thick beds forming one mass of matted leaves occur, but the only marine fossils, which are doubtfully included in this group, are some few and not

very perfect casts of shells, among which univalves are most numerous. At a short distance above the typical rocks of the series the marine tertiary fossils begin to appear, and some strong beds of laterite still occurring in that formation seem to link this portion to the lower group.

The following sections taken from field notes will help to convey a general idea of the sub-tertiary beds—

SECTION NEAR WAG-KA-PUDDUR.

Natural order.

6.—Ferruginous bed with concretionary lumps of iron ore.

5.—Blue and brown shales, thinly laminated gypseous above with rusty layers and yellow ochreous concretions and vegetable markings. Lower part darker and bituminous, with leaf impressions, &c.

4.—Blue-gray unctuous bed without lamination; where damp, plastic; and where dry, the surface disintegrates to powdery incrustations.

3.—Faintly colored and white smooth magnesian (?) soft rock very irregularly deposited, without lamination. Colors of the most delicate tints pale greenish white, creamy white, pink, &c.

2.—More strongly and richly colored white, steatitic (?) rock, red, purple, lavender and mottled, traversed by tangled ferruginous strings.

1.—Soft white aluminous bed with a sooty black hæmatitic mineral largely segregated in it.

X.—Gray augitic trap weathering with a glistening greenish crystalline surface.

„ Stratified traps.

SECTION NEAR MHURR.

Natural order.

6.—Yellow clays and shales—Tertiary.

5.—White unctuous clays alternating with beds of laterite.

4.—Shaly layers and red and white clays, some thin bedded.

3.—A thick irregular stratum of red and white earthy soft unctuous breccia, with large 'spauly' spheroids, the centres of which are of crystalline trap.

2.—Iron stained concretionary crystalline trap.

1.—Dark gray traps.

SECTION NEAR RUTTRIA.

Natural order.

5.—Brown and purple laterite earthy with glazed surfaces.

4.—Pale purple mottled, and white thick unctuous earthy rock with lenticular and irregular interstratifications of coarse gravelly quartzose sandstone and shale.

3.—Strong brick-red brecciated laterite.

2.—Red shales very friable, and pockets of white clay.

1.—Thick amygdaloid weathering greenish with irregular surface.

All the beds of this section are extremely irregular.

SECTION AT JUNAN KUBBEEB ISLAND.

Natural order.

		Ft.	In.
Sub-tertiary.	4.—Blotchy laterite with irregular masses of white clay rock below, penetrated from above by stalactitic masses of the laterite	13	0
Jurassic ...	3.—Red flaggy beds	2	6
	2.—White and pale gray shales with *Corbula*, *Cucullea*, *Gonomya*, and other fossils ... ...,	6	0
	1.—Red bole and white and yellow clays with highly ferruginous bands	21	0

Relations of this group in Kutch and in Surat country compared.

Before passing on, it may be well to allude to the occurrence of a lateritic zone associated also with agatiferous beds and some white and mottled argillaceous rocks at the junction of the tertiary and stratified trap formations in the Surat Collectorate and along the western base of the Rajpipla hills between the Taptee and Nerbudda rivers; most of the laterites being, like the upper ones of Kutch, interstratified in the tertiary [nummulitic] beds.

All these Gujrat tertiary beds are considered to be unconformable to the stratified traps of that region.* Evidence of this unconformity is wholly wanting in Kutch, unless the occurrence of the agatiferous laterites or that of trap pebbles in beds believed to represent some of the newest tertiary deposits, here apparently quite unconformable to the rest of that group, be looked upon as a parallel case.

But the agate-bearing laterites of North-Eastern Kutch are far removed from the stratified traps, resting to their entire exclusion upon

* Mem., Geol. Surv., India, Vol. VI, p. 223.

jurassic rocks; and unless these laterites themselves represent some variety of volcanic 'derivate' rock, the source of the agates rather widely disseminated in them is somewhat mysterious, there being no evidence that the bedded traps ever existed in that part of the district, nor does any outlier of them occur within a distance of about forty miles.

That the lower tertiary beds in both regions represent the same period is more than probable, both being characterised by the presence of a nummulitic group and other tertiary fossils, many of which will doubtless prove to be the same, and both containing interbedded laterites. Below all these there is some slight evidence of the re-appearance in Gujrat of the Kutch sub-tertiary group; but this is weakened by so little being seen, and their derivative character, with other appearances of unconformity between these Gujrat traps and tertiaries, still presents a difficulty in reconciling the general features of the two regions.

It seems possible that in so vast a trappean area as that of Western India, the volcanic activity may not have been everywhere contemporaneous, and that some of the Gujrat traps may have been subjected to denudation before the close of the eruptive period in the Kutch area. The last eruptions of unusually ferruginous and earthy lavas may have been subaqueous, if not submarine or only partially terrestrial, and rivers from the neighbouring land may have brought down the dicotyledonous and other leaves to be mingled with, and have their forms preserved in, strata perhaps largely made up of re-arranged volcanic mud.

Similar eruptions may have simultaneously occurred in the Gujrat direction, the relations being less perfectly seen; or the denudation of the traps may have commenced at a somewhat later period than has been supposed, the uppermost traps of Kutch then remaining submerged, or at least the portions which formed the land being now untraceable.

TERTIARY.

Different groups.

The rocks of this formation comprise several groups, each characterised either by some petrological peculiarity or by the prevalence of certain fossils. The whole formation is, however, subject to irregularities, very likely to mislead, and not only are whole groups wanting in some parts of the area, but individual beds vary along their extension, or die out altogether, so that the sub-divisions to be just now described, though made with care, are occasionally open to some amount of uncertainty.

The rocks.

The beds present a large and varying series of alternations of shales and clays with sands and sandstones, marly and sandy aluminous beds, calcareous marlstones and grits with conglomerates and gravels in the upper part of the series.

Local unconformity.

The higher beds have but faint representatives in the western side of the province, nor are the lower ones found to the east; and as several local unconformities occur, and oblique lamination is very prevalent, the beds being generally nearly horizontal, it becomes a task of considerable difficulty to correlate the evidence afforded by different distant sections so as to generalise with regard to the whole formation.

Nummulitic.

The marly and calcareous nummulitic beds occur near the base of the series, between two zones of shaly rocks containing fossil leaves of terrestrial plants. The lower of these zones is closely associated with the upper beds of the sub-nummulitic group, so closely indeed that it is not easy to separate it from them.

Fossiliferous beds.

The most fossiliferous deposits (excepting the nummulitic ones) are found in the middle of the series; and from the fact of their being developed only in the west, it may perhaps be inferred that the sea of that period did not extend eastwards, the places in that direction where higher beds are now found not having been then

Higher beds.

submerged. In these upper beds only pebbles of trap, agate, and sandstone, have been met with, in conglomeratic layers showing the unconformity of that part of the series to the stratified traps, on the denuded surface of which they sometimes rest.

This unconformity has not been found among the lower beds of the group already mentioned, nor yet between them and the nummulitic subdivision, and is but obscurely traceable amidst the many irregularities which accompanied the deposition of the soft upper rocks of Kutch. The equivalents of these upper beds in the western portion of the district may be certain thick conglomerates made up of older tertiary rocks, sometimes wholly of nummulites washed from their original matrix. The friable nature and sub-recent aspect of all these upper beds, and the impossibility of tracing their uncertain stratification for any distance, together with the general absence of organic remains, present great difficulties in attempting to classify them with accuracy.

The sub-groups into which the formation has been divided provisionally are as follow :—

Descending order.

			Probable thickness.
F	? Pleiocene.	Variable and inconstant deposits, including concrete beds of great thickness.	200 to 500 ft.
	? Meiocene.	Soft sandstones, shelly, calcareous and quartzose grits, gravels and conglomerates with trap pebbles and agates. Brown sands and sandstones with fossil timber.	
		(Unconformity.)	
E	? Upper Eocene, or Meiocene.	A great thickness of clays and shales alternating with sandy shales and harder bands of shelly limestone, or marls; a few nodular clay and conglomeratic beds. In the upper part fossils are most abundant, often forming whole beds. The lower part is often rusty brown and sandy, with ferruginous and lateritic bands and some conglomerates. Some of the sands are richly mottled and in parts white. Some large bones, &c., in one of the lower conglomerates.	800 to 1,200 ft. (?)

Eocene.	D	Mottled, white, iron-stained, streaky, fine silty sandy shales, soft and friable, obliquely laminated, irregularly bedded and often lenticular; contain impressions of leaves	100 feet.	600 to 800 ft.
		Dun colored and blue silty clays and blue shales; contain the carapace of a minute crab, &c. ...	80 feet.	
	C	Marly beds with a few fossil casts and nummulites in lower part.		
		Nummulitic marls and limestones	700 feet.	
	B	(?) *Operculina* gypseous shales with nodular bands and laterite above and below. An oyster bed sometimes on this horizon	100 feet.	
	A	Finely laminated shales, upper part rusty brown and friable; lower argillaceous and bituminous and pyritous, with small lumps of mineral resin, bitumen, &c. Small horny plates, possibly belonging to a crustacean, and woody fragments and leaf impressions best preserved in the lower part.		50 to 100 ft.
				TOTAL 1,600 to 2,600 ft.

The last-named beds are intimately associated with, and sometimes appear to form a part of the sub-nummulitic division with its mottled lateritic and (?) volcanic beds.

Portion of the group succeeding the volcanic looking sub-nummulitic beds.

A.—The fossiliferous and shaly portion of this group is inconstant, and not found in more than a few places. The contained leaves are of several kinds, both exogenous and endogenous, occurring locally in great numbers, generally small and lanceolate, but sometimes of large size; the fine deposits which contain them may have been local river, lacustrine, or estuarine, accumulations.

Gypseous shales.

B.—This is also a band of comparatively local character, occurring just beneath the nummulitic group round the western curve of the beds which flank the Gaira hills, and in a few other places. Its nodular claystone and marl bands and some of the shales are full of little *Nummulites* and *Operculina*, and a few other marine fossils, such as *Corbula*, *Ostrea*, &c., the latter chiefly in the upper part; and they also contain bones, reptilian remains and fish

vertebræ and teeth. In one place some *Anomia (Patro) elyros,* Gray (?), and oysters were found within a few feet of the nummulitic beds, which rest apparently in regular conformity upon these; while in another some mottled and variegated friable clay shale and lateritic beds intervened between the two sub-groups. The thickness of this sub-division may vary from 50 to 150 feet.

Nummulitic group.

C.—The nummulitic group of Kutch consists of pale yellow and white marly impure limestones with some sandy beds and shaly marls. The *Nummulites* as usual abound, comprising several varieties; and *Alveolina (Fasciolites)* are locally numerous.

Many *Echinoidea* occur in the upper white beds, *Clypeaster, Spatangus,* and *Galerites* most usually and locally abundant; and they also contain a few bivalves and gastropods, including *Pecten, Pinna, Spondylus, Ostrea, Turritella, Cerithium, Conus,* &c. Rib-bones are also sometimes met with.

Some of the nummulites are peculiar to certain zones in the group, and at the period when these deposits ceased corals seem to have flourished; large coral masses being found wherever the upper beds occur. These great brain-corals are, however, so crystalline in general that little of the organic structure can be seen except on a large scale. The isolated and flat-topped hill of Gade-Puthar, near Khoodee and five miles south of Narainsir, is probably an old coral reef.

The stratification of the nummulitic group is regular and parallel as might be expected in pelagic deposits; but the whole group dies out or disappears with much obscurity at the eastern limit assigned to it upon the map: slight representatives of it, however, re-appearing much to the south-east or to the east of its general development, the margin of which on that side is not only disturbed and faulted, but the rocks are much concealed by sub-recent alluvial and river deposits.

Arenaceous group.

D.—The beds which succeed the nummulitic group in different parts of its area are variable and inconstant, sub-group D being sometimes entirely absent. Where this is found, it is characterised by very irregular and false-bedded sand or friable sandy shales generally white and streaked by iron-stained laminæ. These rest on dun colored and blue finely laminated clays in which only a few fossils, including casts of a small *Donax* (?) and the carapace of a very small crab, were found. In the sands above are impressions of several varieties of exogenous leaves.

Beyond the termination of the nummulitic beds near Kannai, a very similar variegated sand, or sandy shale with leaves, occurs intercalated between marine beds of the next succeeding sub-division; it is, however, a very local deposit and soon thins out, but may represent the leaf beds just mentioned.

The fugitive character and irregular aspect of the group D suggested to Mr. Fedden the possibility of an unconformity between the nummulitic beds and the group E, though this was hard to establish owing to the horizontality of all the rocks where junctions are seen.

ARGILLACEOUS GROUP.

Argillaceous fossiliferous groups.

E.—This is by far the most important of the Kutch tertiary deposits in thickness, extent, and the number and variety of its fossils. Among its basal beds are some much resembling the upper portion of the preceding sub-division, variable and false-bedded on a large scale, but not found to contain the leaves there met with, except in the case just now noticed. Strongly ferruginous or lateritic bands also occur, and this lower portion has in general a rusty appearance. Soft brownish, yellowish, or mottled sandstones with ill defined lamination (or none perceptible) prevail, often characterised by cylindrical, concretionary, ferruginous or white, ramifications or casts of burrows.

Turritellæ, &c., with *Corbulæ* and *Venus granosa*, occur abundantly in one or two of the ferruginous bands and also in nodular lumpy conglomeratic clay beds seen at intervals above, in which were found fragments of *Echinoidea*, *Foraminifera*, *Bryozoa*, and a large species of *Amusium*.

The *Turritella*-marls and marly sandstones form a well marked zone, in which at one locality a number of very perfect specimens of crabs were obtained, and also quantities of large rib-bones with one shark's tooth. A coralline bed occurs on or about this horizon, and a little higher some marly limestones and shales with a variety of fossils, *Orbitolites* and *Operculina* being very abundant, as also *Pecten*, *Ostrea*, *Venus*, *Cardium*, *Strombus*, *Natica*, *Clypeaster*, *Spatangus*, *Balanus*, and small square palatal fish teeth, &c., &c.

It is probable that some of the nodular and ferruginous beds represent those of Perim Island in the Gulf of Cambay, distinguished by an abundance of large mammalian bones (described by Captain Fulljames and others, *Jour., As. Soc., Beng.*, v., 289. See also *Geol. papers on W. India*; *Mem., Geol. Surv., India*, vol. vi, p 182); since one or two large bones and two fine molars of a bilophodont (? Lophiodon) were found in the valley of the Mhuror river, in ferruginous or lateritic beds believed to belong to this group.

Above the beds hitherto described are calcareous grits and sandstones with sandy beds more or less compact, and flaggy bands. In these fossils are scarce, but *Balanus*, a small oyster, casts of *Turritella*, and shark's teeth were found. To them succeeds a large thickness of argillaceous rocks—shales, clays, and marly beds; the lower shaly clay beds containing thin disc-shaped *Nummulites* and other Foraminifera, while in some of the more rubbly shales, *Placuna* and *Placunanomia*, oysters, &c., are common.

At about the middle of this great argillaceous band, the most fossiliferous beds of the whole series are found, consisting of yellow marls and

marly limestones, and hard muddy beds, some being almost entirely made up of fossil shells (converted into yellow carbonate of lime) or distinguished by a great abundance of Pectens or oysters, while, on the whole, Gastropoda predominate.

Amongst those collected from this zone are the following genera:—

Neptunus.	*Natica.*	*Ostræa.*		*Balanus.*
Palæocarpilius.	*Cypræa.*	*Spondylus.*	*Tellina.*	*Serpula.*
Turritella.	*Cerithium.*	*Pecten.*	*Anomia.*	*Bryozoa.*
Conus.	*Scala.*	*Pectunculus.*	*Placuna.*	*Clypeaster*
Fusus.	*Solarium.*	*Modiola.*	*Corbula.*	Spines of *Echinoderms.*
Oliva.	&c.	*Venus.*	&c.	*Corals.*
Rostellaria.		*Cytherea.*		&c.
Pleurotoma.		*Cardium.*		
Voluta.		*Arca.*		
Murex.		*Nuculana.*		

The argillaceous beds immediately succeeding the highly fossiliferous zone consist mainly of soft sandy clays and muddy shales, with a few compact sandstone layers thinly laminated and ripple marked, and a narrow band largely made up of fragmentary shells with clusters of barnacles upon its surface. Higher up the beds contain bored clay nodules resembling pebbles, Bryozoa encrusting the shells of Pectens and oysters, and one soft sandy band full of casts of a little *Cerithium*, resembling *C. conicum*, &c.

The higher beds of this group have often been removed by denudation prior to the deposition of the next.

UPPER TERTIARY.

Upper Tertiary.

F.—The unconformable group has at its base a conglomerate in places more or less ferruginous, but of no great thickness; this is succeeded by thick-bedded brown sands or incoherent sandstone, parts of which near the base are connected by carbonate of lime; calcareous segregations also occur throughout the rock, and the only organic remains found were a few large logs of fossil timber.

The upper members of this group are ill defined, the most recognisable being a great thickness of obliquely laminated concretes some-

times nodular and kunkury, with large fossil oysters *(O. lingula?)* not unlike some of those now living on the coast of Kutch. As these beds are by no means constant, their further description will be better reserved for the part of this report dealing with local details.

ALLUVIUM.

The alluvium of this country is the result of degradation of the local rocks. As most of it overlies the tertiary beds, which must have been heavily eroded to form the plains, it consists largely of materials derived therefrom, frequently mingled with travelled fragments brought by rivers from the hills. Much of it is a kunkury deposit or mottled clay with red blotches and quartz grains, resembling a newer tertiary stratum, and thought by Mr. Fedden to belong to an older period than the rich brown loamy alluvium, which sometimes approaches to the character of 'regur.'

Very generally distributed over the hilly country, is the sub-recent calcareous deposit already alluded to. The white sandstones of which it consists are sometimes sufficiently coherent to be used for building, and it is very commonly burned for lime all over the province. No fossils have ever been found in it, but on some slabs, from the deposit in Western Kutch, tracks of crustacea or of annelids have been observed. It is not limited to a uniform level in its various situations, having been met with in the low ground at the foot of hills bordering the Runn, as well as high in their glens. Its aspect is always very much the same, though its texture is varied, being sometimes conglomeratic or finely oolitic, and generally it presents much oblique lamination.*

* Possibly this may be the rock alluded to by Carter in the '*Summary*', *Geological Papers, Western India*, p. 568, as mentioned by Colonel Sykes, Geological Society Transactions, Vol. V, p. 716, under the name of Oolite, and considered by Dr. Carter to represent the 'Miliolitic formation" of the Arabian Coast. If so, it does not contain organisms in Kutch so far as microscopic examination goes.

The sand dunes along the coast do not require more than passing notice, being in every respect the same as such usually are. Their ridges in several places have a bearing of about 20° north of east and south of west.

The question of how the alluvial plains of the coast of Western India were formed, is not cleared up by anything observed in Kutch. The materials are often but not always of fine grain; they sometimes contain near the surface a few land shells, but no marine remains have been detected. The deposits frequently resemble those of rivers; but there are no large rivers in Kutch, and the small intermittent streams which it possesses, would have to wander laterally to a very great extent in order to cover the country with such detritus. They only appear to have changed their courses in a few localities near the coast, and their valleys though small, are generally single and separate from the hills to the sea.

The alluvium may be marine, but in the absence of fossils this cannot be asserted, and the configuration of the ground it occupies differs both from that of the Runn and from that of the neighbouring sea bottom as shown by the coast survey soundings, being apparently less level than the former, and less uneven than the latter.

CHAPTER VIII.—SUMMARY OF THE SUCCESSION OF THE DIFFERENT FORMATIONS AND THE CONDITIONS ACCOMPANYING THEIR ACCUMULATION.

It may be advantageous here to recount briefly what may be learned from the formations previously described as to the conditions and order of sequence under which they originated.

Unconformity of lower jurassic and metamorphic rocks.

Although no basement-junction of the jurassics has been found, it may fairly be inferred that they rest somewhere upon the metamorphic rocks of which a portion is exposed in Nuggur Parkur; for some of the lower beds in the island of Béla and elsewhere have been found to contain a few rolled syenitic, hornstone, quartzite and other metamorphic, pebbles, pointing to an unconformity and a period when the metamorphic rocks underwent denudation simultaneously with the deposition of the lower jurassic beds. The scarcity of these pebbles may also indicate both distance from their source and probably a considerable accumulation of the marine jurassic beds earlier than those in which they have been found.

The shales and sandstones of this lower jurassic period of Kutch are proved by their fossils to have been mainly of marine deposition, if not entirely so, the few cases in which terrestrial forms have been found interstratified pointing to the supposition that these land fossils were washed into the seas or estuaries of the time.

Upper jurassic.

The upper jurassic beds containing both marine and terrestrial fossils present no change of aspect sufficient to indicate that they were of lacustrine origin or deposited mostly in fresh-water, so that the same reasoning with regard to the presence of terrestrial plants may be applied to this group. In its general aspect this part of the formation has less of a deep-sea character, less appearance of tranquil deposition than the lower beds, and its

frequently cleanly washed, coarse grained, and obliquely laminated, beds would seem to indicate shallow agitated water as a condition of their accumulation. This being the case, the small amount of alteration requisite suggests the probability of the occurrence of estuaries or back-waters or fresh-water lakes here and there during the deposition of these rocks.

Subsequent to their deposition these upper jurassic rocks suffered an apparently unequal amount of denudation, they at the time, in some cases certainly, having formed land. A great change then took place, and the jurassic formation, whether as land or under water, became covered locally by earthy and sandy deposits largely composed of igneous materials, and generally by volcanic flows; among the earliest of these some small fresh-water lakes existed, wherein fish and molluscs lived. The sources of these volcanic flows are not accurately known; but it is most highly probable that they issued from the numerous fissures now occupied by traps in the jurassic rocks. Some doubt may exist as to whether these are sufficiently numerous for all the overlying trap rocks to have thus found vent; it should however be remembered that such sources may be at least as numerous in the area beneath the traps themselves as elsewhere, though probably frequently overlaid and entirely concealed by superincumbent masses of trap, or, by reason of the similarity of the rock, not making themselves manifest at the present surface of the ground.

Traps.

The question of these traps having been mainly subaqueous has been already referred to; this view appearing to me the most probable, from the absence of the cones and craters which generally distinguish terrestrial volcanic regions.

At the close of the trappean period some volcanic flows of widely different aspect from the rest supervened, sources for which appear to be strongly indicated by the occurrence of similar rock in dykes through the jurassic formation, either occupying fissures by themselves or sometimes lying along the sides of other

Sub-nummulitic group.

dykes of the darker and older trap; the latter situations evidently being lines of weakness where newer intrusions might be expected to occur.

Associated with these rocks are the laterites of Kutch, but whether as derivative beds, or as altered or original traps the evidence to be obtained from their occurrence in the field is not of itself sufficient to show. This form of rock has not certainly been found intrusive in dykes, but is closely associated with the newer volcanic beds or flows, and although beds of it occur for some distance upwards into the lower tertiary deposits, it has never been found to contain a single organism.

Nothing has been found to prove these later volcanic and lateritic beds unconformable to the older stratified traps, and though both are azoic, there are associated with them certain shales which are in places crowded with the forms of leaves belonging to the two great vegetable classes, but which have not been observed to contain any marine organisms. Very shortly succeeding these, however, the marine tertiary fossils appear, *Ostrea* and fish being among the earliest forms.

Tertiary.

The lowest tertiary beds succeeding the traps (these being believed themselves to be of early tertiary age), including the nummulitic group, appear to have been deep-sea deposits; and the succeeding beds again afford evidence in their leaves either of lacustrine or estuarine conditions or of vicinity to the margin of the land. Marine beds, locally abounding in fossils, succeed to these, the fossils indicating frequently the presence of littoral regions; and then a break and unconformity occurs, the newest or upper tertiary beds having either a strongly shore-like or approximately recent aspect. Marine fossils are still found; but in much of this upper part of the formation fossils of any kind are absent.

Alluvium.

The overlying alluvium and sub-recent deposits, except in their most superficial portions, contain no evidence as to the conditions under which they were accumulated; and where they do enclose organisms these are, as usual, terrestrial and recent shells, &c.

CHAPTER IX.—ECONOMIC RESOURCES.

Coal.

The coal of the jurassic rocks of Kutch attracted some attention formerly; but the quantity found appears to have been always too limited and the coal too impure to have encouraged its being worked extensively.

The workings at Trombow were the largest, but are now closed by the falls from the roof of the adit. Mr. Blanford, however, was able to measure the seam; the dimensions of which, 1 foot 4 inches, included so much shale that only 8 inches was found to be good coal. Several other seams are stated to have been found, chiefly in the neighbourhood of Seesaghud (Colonel Grant's paper); but all too thin to repay the cost of working. Carbonaceous shale with coaly layers occurs in the river north of Seesaghud; and a coaly shale of which 2 feet was visible, was found in a stream course west of Gooneeri, near Lukput. The coal occurred as usual in thin bright layers between the laminæ of the shale, bearing a strong resemblance to some found north of the old workings at Trombow, and perhaps lying on nearly the same horizon.

None of these coals seem to have been valuable; and even if the beds were thick, the intermixture of shale would be against them while the frangibility of that found near Seesaghud is said by Grant to have been such that it fell through the gratings of the furnaces. All that has been seen in the district, broke up into minute fragments on exposure, and no piece of even an inch square could be extracted from the beds.

The most clearly seen sections indicated rapid thinning out of the coaly portions, so that the existence of extensive workable deposits seems more than doubtful, if not altogether hopeless.

A few thin carbonaceous layers of shale have also been met with in the tertiary beds but none of them were at all promising.

Iron.

The iron formerly manufactured in Kutch was derived from either the hæmatitic laterite of the sub-nummulitic group, or from some highly ferruginous deposits largely impregnated with this ore, occurring near Bucháo; the age of which is somewhat doubtful, beyond that it is associated with the stratified trap, and believed by Mr. Fedden in part to underlie the latter.

The iron to judge from small specimens appears to have been good; but smelting operations have been discontinued for some time in consequence of the facility with which foreign iron can be obtained. The principal places where the manufacture was carried on were the neighbourhoods of Buchao, Loonwa and Doodaee in the eastern portion of the central plain, and Mhurr at the western side of the province; but some ancient smelting places, of which the present generation knows nothing, existed near Vittrooe hill in Wagir, (and probably also elsewhere.)

Several of the jurassic beds are so ferruginous that some iron might be obtained from their hæmatite.

Alum.

Alum is manufactured to a large extent at Mhurr during certain months of the year; and the works are reported to have been carried on for the last five or six centuries (Grant). The material used is a pyritous dark gray or black shale closely associated with a soft aluminous pseudo-breccia of the sub-nummulitic group. This appears to overlie or enclose the shale, or to have invaded it, as fragments of the shale form a coarse angular breccia with the aluminous rock as a matrix in some parts of the works. The native burrowings, however, afford very poor opportunities of studying the relations of the rocks, the air in them being so bad that it is difficult to obtain light; and much of the ground may have been disturbed by '*Old mens*' workings, these being stated by Colonel Grant to fall in every year. These works are narrow passages sunk after the manner of some wells vertically for 22 'guz' (cubits) with a rude incline to descend. They are then carried anywhere horizontally into the deposit and are

said never to have been driven down through it owing to the accumulation of water.

The shaly rock is excavated during the rains and exposed for four months in heaps, when a slow combustion takes place from the decomposition of the pyrites. It is then spread in squares resembling salt pans and sprinkled with water, after about twelve days it consolidates into efflorescing and mamillated crystalline plates or crusts called *phitkárí-ka bíj* or *binj* (seed of alum). These are boiled in water in large iron vessels (luted inside with lime) mixed with (*'súra kar'*) saltpetre (or other potash salt) in the proportion of 15 of the 'alum seed' to 6 of the latter; when it has settled the fluid is placed in small earthen vessels, somewhat the shape of small flower pots; crystallization takes place in three days. These crystals are again boiled one or more times to concentrate the solution, which is finally ladled into large thin bladder shaped earthen *mutkas* or *ghurras* with small mouths; these are sunk in the ground to prevent their breaking, and in five days the alum is found crystallized in masses. The vessels are then broken and the alum removed to a storehouse, the entrance to which is built up until a favorable market can be obtained.* The quantity said to be annually manufactured equals 8,250 maunds of 40 seers or 80℔s each. The saline water of a warm spring which rises from a fault north of the town of Mhurr is supposed to be superior for the purpose of manufacturing the alum, and is largely used.

Alkaline salt. *Soora kar.*

The alkaline salt, largely composed of potash, which is used in the alum manufacture, is made in various places all over the country. The village refuse (litter, bones, &c.,) is collected and burned, placed over rude filters formed of

* This account given by the Native Superintendent coincided nearly with those furnished by Colonel Grant and general Sir G. Le Grand Jacob, but the amount manufactured according to the latter was, when he wrote, apparently much greater, (50,000 maunds—? kutcha).

bushes and treated with water; the percolating fluid is then collected and boiled down, and the impure salt resulting sent to the alum works at Mhurr under the name of *súra kar.*

Incense.

Some friable brown shales in the sub-nummulitic and next succeeding beds contain small resinous and black bituminous lumps, which are burned in the native temples as incense. The substance is called *(butkhánah)* (*' bootkana,'* Sir G. Le Grand Jacob's paper) at Mhurr, where it is found and it also occurs at Joolerai and near Lukput. To the eastward of the latter place it was observed in small quantities in tertiary shales, which from their position should be slightly above the nummulitic group.

Salt.

Nearly all the rocks of Kutch are strongly impregnated with chloride of sodium and other salts; to such an extent indeed that a stream of fresh water is rarely to be found in the country except in the stratified trap area. The upper jurassic and lower tertiary beds, including the sub-nummulitic group, are the most saline, but efflorescences of various salts are very common. Some asbestiform aluminous salts cause exfoliation of the interior surfaces of old workings at Mhurr; and others occur in the same rock group (sub-nummulitic) north of the village of Furradee in the Kanta. One of these with finely capillary crystallization forms white nests under a blistered saline crust in the bed of the stream here.

The bed of a dried up tank near Bhootukia in Wagir was observed to be covered with a strong white deposit of crystalline salt. This was, however, an unusual occurrence, others not showing a deposit of the kind; but many of the river pools were lined with an incrustation of salt.

The salt on the Runn has been already mentioned. It is collected in places but does not form an article of export, although it might be obtained in enormous quantities.

Lime.

Lime is obtained from the sub-recent concrete or calcareous tufa, widely but irregularly distributed over the country.

Gypsum.

Large quantities of gypsum occur in shales belonging to the jurassic, sub-nummulitic, and tertiary groups; the most highly gypsiferous being those of the sub-nummulitic band. The mineral is generally translucent; and clean blocks up to several inches by two or three may be found weathered out on the surface of the ground. Although much of it might be obtained without greater trouble than picking up the pieces, it does not appear to be utilized except to a slight extent by goldsmiths, who are said to use it in a powdered state for polishing their wares. Among other places it occurs—near a small outlying patch of tertiary rocks on the Runn east of Adeysur; near Chitrore; between Adhooe and Badurgud; all in Wagir:—and in the western part of the district about 2 miles south-west of Mhurr; also east and north-east of Oomirsir and nearer Lukput.

Ochre.

Some of the decomposed red highly ferruginous beds of the sub-nummulitic series near Lukput are quarried, and the mass exported to form a colouring material or dye.

Colouring materials.

The pale whitish shales of the jurassic rocks are very generally used to make a kind of white-wash for the humbler dwellings of the natives. And the unctuous greenish and white aluminous rocks of the sub-nummulitic band are used as soap, being believed to have particularly cooling properties. Some similar rock occurring as a pocket enveloping a mass of sandstone in an intrusion of ordinary doleritic trap near the village of Ruttria (*i. e.*, red) is excavated for sale in the bazaar at Bhooj. Some of the soft white aluminous beds of the sub-nummulitic band are mined after a fashion, on the west side of Babooa hill in the Gaira country, the material being exported at Kotésir.

Millstones.

The silicious ferruginous grits with quartz grains which occur both in the jurassic and sub-nummulitic groups, and a very similar rock of nearly black colour in the tertiary beds, at Karimori hill, furnish strong tough millstones. These are also obtained from the ferruginous quartzite-like grit of a long ramp near Chundeeya, west of Anjar.

Building stone.

Building stones abound in Kutch, the traps only not being extensively used for this purpose. Some of the best varieties are furnished by the lower jurassic rocks; and others much used are got from the upper tertiary beds; but any of the sandstones of the country are employed, though many of them are so soft and saline that they rapidly decay. The sandstones being so plentiful and so easily worked they seem to have been often preferred to better stone which might have been found either among the traps or elsewhere. Stone but slightly if at all saline is called *meeta* and that impregnated by salts, *kara*. The latter is of course more perishable.

Lower jurassic.

The finer grained slightly calcareous yellow sandstones of the lower jurassic group form tolerable building stone; and some of the close hard silicious grit bands, though difficult to trim or dress fine, would afford a very lasting material for rough work. Limestones in this group also furnish good black or gray or orange stone, the former procurable from the Lodye and Joorun range near Hubbye or the Júria hills, north by west of Bhooj, and the latter occurring in quantity at Raimulroo hill near Kaora, and in several other places in the Putchum chiefly along the Kala mountains.

In the Putchum also and at other points of the Runn Island chain, some thin-bedded red or yellow calcareous rock largely composed of broken shells is found. This takes a good polish and has received the name of Dokawana marble; thin layers of it occur in other parts of the district also in the lower jurassic rocks.

In many places good level flags of fine and coarser grain occur likewise in this group.

Intermediate beds.

The upper beds of the lower jurassic, or the lower ones of the upper group being often thin-bedded sandstones alternating with shales would furnish building stones occasionally of fair quality.

Upper jurassics.

The sandstones of the upper jurassic group are, as a rule, too coarse and friable to afford good stone for building purposes, though several of the more ferruginous varieties have been largely used as well as some of a yellow or whitish colour.

Traps.

Among the traps there are several solid basaltic varieties which from their resistance to the wasting effect of the atmosphere would stand well in buildings, but their hardness seems to prevent their use. There is no reason why building materials of the same character as those of the rest of the Deccan trap should not be found among them, to which the remarks of Mr. Blanford* would apply with equal force, their natural state of weathering being the best guide to their selection.

Tertiary.

The harder marly beds of the tertiary rocks are frequently used for carving, in ornamental and other buildings; although they are easily worked and look well, they deteriorate quickly, flaking off where exposed to the weather, as may be seen in the neighbourhood of Vinjan. More highly calcareous varieties of course last better, and among these much stone of fair quality might be obtained.

Upper tertiary.

Beds of calcareous quartz grit, thick yellow sandstone or conglomerate and concrete, belonging to the upper tertiary rocks are quarried for buildings in the neighbourhood of Toona, in the Kanta generally, and other tertiary parts of the district;

* Memoirs, Geol. Surv., India, Vol. VI, page 217.

and some fine calcareous and argillaceous *meeta* rock quarried at Gooniasir near Assambia is largely employed for carved work at Mandavee.

Sub-recent concrete.

The sub-recent concrete or calcareous tufa formation occurring extensively throughout the district in many places contains even beds of coarse soft calcareous sandstone which are often worked only by pick and bar, and produce a fine white stone not unlike that from Pore-Bunder (Kattiwar) at a little distance. and which from their durability, though always rather soft, seem to harden nearly as much as they disintegrate under the action of the atmosphere, This stone is largely quarried on the road from Mandavee to Bhooj, at the ghat descending to the Bhooj plain along the Charwar and Katrol range, and in various other places, either for building or for burning into lime.

Littoral concrete.

Along the coast at two or three places westward of Mandavee a littoral concrete worked between tides is used for the construction of wells, &c., and was the material proposed to be used for a pier or jetty at Mandavee. It is formed of the shore-sand consolidated and cemented by carbonate of lime, and is said to be about two feet in thickness.

The following list of building stones used at Bhooj has been supplied by the Dewan to His Highness the Rao of Kutch—

No. Name of stone.	Locality.	Stone.
1—Cheethurio pronounced Cheethureea ...	4 miles north of Bhooj	Lr. jura—sandstone.
2———— ...	Nabhoe or Nambye—south-west of Bhooj about 20 miles—...	Ditto Fine gray grit. This makes good sharpening stones.
3—Meereean ...	Baoka, 8 miles W. N. W. of Bhooj	Sub-recent concrete sandstone, good for lime.
4—Ditto ...	Mandavee Road Bridge, 6 miles from Bhooj	Ditto.
5—Ditto ...	Karejur, Katrol range S. of Madapoor, 4 miles from Bhooj	Ditto.
6— ...	Kaora, 42 miles north of Bhooj	Lower jura—limestone.
7— ...	Hubba or Hubbye Hills between Kota and Lodaee	Lower jura—dark gray limestone.

8—Karo Bhato	... Near Baoka	Red sandstone quarry exhausted.
9 ———	... Vinguria, 18 miles south-west of Bhooj	... Lower jura—brown sandstone.
10 ———	... Wurrar Hill, west by north of Bhooj	... Lower jura—pale red sandstone.
11 ———	... Duggera, 20 miles east of Bhooj between Danatee and Kunyabuy	Upper jura—fine sandstone? Slightly calcareous.
12—Datta	... Near Parade ground, Bhooj Camp	Upper jura—coarse sandstone, silicious.
13—Kala-putter	... Ruttia or Ruttria, 3 miles from Bhooj to west...	Upper jura—ferruginous sandstone.
14—Rutti Khan	... Kara Nuddi near Rodur, 6 miles from Bhooj to north-east	Transition jura—fine red sandstone.
15—Kara Bookaria	... Bhooj	Upper jura—soft sandstone, saline.
16—Meeta Bookaria	... Near south-west of Residency, Bhooj...	... Ditto ditto not saline.
17 ———	... Luckee Hills near Sairat.... ...	... Upper jura—red sandstone.

NOTE.—Some of these villages have not been marked on the maps owing to uncertainty as to their exact position.

NOTE TO PART I.

The use of the terms "lower" and "upper" in connexion with the *jurassic* or *tertiary* series in the foregoing part of this memoir, must be clearly understood in the sense in which they were applied in the field—merely as meaning *lower* and *upper* (physically) groups of Kutch, leaving for the present undetermined their more or less complete correspondence with the jurassic and tertiary formations of other places.

The laborious examination of a large palæontological collection, such as that obtained from the province, would necessarily occupy a much longer period than it was considered advisable to delay the publication of the field work. This examination is now only so far advanced as to enable some general conclusions to be arrived at, pointing to the probability that the oldest or lowest of the jurassic rocks of this district will be found to correspond to the Bath oolite of England, and, therefore, to occupy a geological position superior to any of the '*lower* jurassic' rocks of European series. Of the middle and upper portions of this series several sub-divisions are partially represented here, the correspondence being so far perfect that the uppermost beds of the marine jurassic group, called in this paper 'lower jurassic' of Kutch, contain fossils which are truly of *upper (European) jurassic* age.

Above these comes the mass of the plant-bearing beds of the district, here called 'upper jurassic,' united to the underlying marine fossil-bearing rocks both by transitional beds, and by at least one undoubted case of intercalation of a *Palæozamia*-bearing zone with others containing marine jurassic fossils. It is, therefore, clear that both of these

groups, the beds with marine fossils and those with plants, together form 'physically' one great continuous series.

Hence, although the *plant*-beds occupy a stratigraphical position, perhaps actually newer than the European 'upper' jurassic or possibly synchronous with some portion of the succeeding formations, still it is, on the evidence derived from this district, impossible to assert that they are of this (?)cretaceous age.

With regard to the tertiary fossils which have been collected, the progress as yet made in their examination hardly warrants any assertion as to the precise place of those sub-divisions which overlie the Kutch Nummulitic group.

Putchum peer Hill.
The highest hill in Kutch.

PART II.

Detailed Descriptions.

As the most convenient form of conveying detailed information relating to the various localities in Kutch, advantage will be taken of the natural arrangement of the formations into more or less east and west belts, coinciding with the features of the country, taking in such detached portions of different groups as by reason of their place may be readily included. Thus it is proposed to commence at the north with the Parkur syenite, &c., then to follow the island range from the Putchum eastward, returning through Wagur to the jurassic tract of west Kutch along the northern watershed, and concluding with the country which sends its streams to the southward. The bedded traps being everywhere very similar, it will suffice to include their description in detail with that of the adjacent country on either side.

SECTION I.—PARKUR NUGGUR.

The bold hills of Kalinjur and those around Nuggur consist of red syenitic granitoid rock, great masses of which rise abruptly from the sandy plains around. It is a homogeneous rock with a foliated appearance on weathered surfaces only, scaling off from large bosses and hollows. A few divisional planes nearly horizontal and about 12 or 15 feet apart are visible in one part of the hills.

A large elvan dyke on the north side of the range runs north-35°-west, and among the hills a lump of basaltic trap was observed, also a piece of hornblendic diorite. No schistose rocks were observed in the neighbourhood of these Kalinjur hills.

In some places bedded sand and syenitic gravel abut against the syenitic cliffs to a height of 200 feet. No shells were detected in this, which, although uncemented rock, may be equivalent to the sub-recent concrete of other places. The spurs and projections in which it is seen afford on a small scale good illustrations of the denudation of hills. The alluvium occupying the lower ground is in places tough, lumpy and kunkury.

SECTION II.—THE RUNN-ISLAND RANGE FROM PUTCHUM TO CHORAR.

The Putchum island, out in the centre of the Runn, is traversed by two somewhat east and westerly chains of hills. Of these that to the north called the Kala Doongur (Black hill) has the most lofty elevation found in Kutch, the summit of Putchum Peer rising directly from the Runn to a height of 1,437 feet,* by aneroid measurement. Like other portions of this chain, the north side of the hills presents a steep scarp exposing contorted beds, which become steady at the top and thence slope at low angles to the southward, with long hanging levels. The contorted state of the beds, at the north foot of the hills and numerous fissures filled with trap, render this part of the section obscure. The beds here are about the lowest exposed in the jurassic rocks of Kutch, and are found to consist of fine white and light coloured silicious sandstone with some calcareous bands and sandy slightly ferruginous purple beds; pale flaggy sandstones also occur, and some peculiar yellowish rubbly bands full of *Nerinea*, &c. There are also red and rusty shaly beds with ripple marks, conglomeritic, and thin shelly bands throughout; but the predominant varieties are white or light coloured sandstones often flaggy. These are all of them more or less fossiliferous, the principal forms being oysters, *Corbulæ*, turbinate *Gastropoda;* and in Kooaree Beyt, among beds ranging from soft raggy sandstone to hard sandy limestone with low curving southerly and westerly dips, many highly fossiliferous layers contain *Cidaris* spines, *Trigonia*, *Natica* and *Nerinea*. Intruded among these lower beds are several doleritic dykes, one of red lava and a considerable mass of black coarsely crystalline augitic trap with closer grained olive veins, near Koorun-wand, which is highly magnetic,

The Putchum, Kala Doongur.

Northern base of Putchum Peer.

* Equal to a depression of 1·6 inches.

in some places reversing the compass needle. Some of the erratics from this trap having much the look of gray syenite suggest the slight possibility of a rock of this kind having furnished the boulder found by Captain Grant in the river near Jam-koonrea, which he describes, however, as identical with the Parkur syenite. Near the intrusion dark altered shelly bands and traps, intimately associated, occur, having an appearance as if some of the aqueous beds had been melted by contact while the traps were being intruded. The regularity of the lines of bedding and the alternation of the rocks in a place, where intrusion was less prominent, might be taken as evidence of contemporaneity: as it is, some of the finer beds have been, at least, intensely altered *in situ*; being in places quite black and splintery, though still retaining traces of fossil plant fragments.

North side of Putchum Peer.

Commencing to ascend the steep face of Putchum Peer, overlooking the Runn, some coarser beds,—gray calcareous bands weathered yellow or brown, and a calcareous breccia with trap and other enclosed fragments, were found, and still further up, hard gray calcareous rocks almost limestone interlaced with trap dykes, also clayey yellow bands and hard 'pencilly'* shale. The dykes here observed were porphyritic with black crystals of augite in a dark gray compact augitic base. Succeeding all these rocks are purple and gray shales and white sandstone massive gray limestone and fine sandstone with a few traces of fossils, purple and greenish variegated sandy shales, white sandstones again, and over all the set of gritty orange limestones and calcareous beds, thick, thin or flaggy, containing *Corbulæ*, *Nuculæ*, *Trigoniæ* and sections of gastropodous shells, which sheets the whole mountain on its south side, and extends nearly as far as to Kaora.

South side of Putchum Peer.

* An expressive term for splintery ('spauly') shale given by Irish workmen to a rock which could be used as slate-pencils.

Some of the silicious limestones of Putchum Peer hill have cherty concretions, a few scattered quartz pebbles, and seem quite as unfossiliferous as the limestones of Sitabund in the Dhar forest, Nerbudda valley, which they somewhat resemble; others are in places crowded with broken fragments showing imperfect sections of univalves, &c. They are quite the same as the strong orange calcareous beds of Raimulrow hill, east of Kaora, which would doubtless form a good building stone, notwithstanding their being deeply eroded by atmospheric action along joint planes.

Summit of hill.

The view from the summit of Putchum Peer is most extensive, the Parkur hills can be plainly seen with a waste of salt and water between them and the observer. The salt extended thence westward, and over it in a direction 30° north of west something dark was seen on the horizon, which may have been the 'Allah Bund.' To the south and south-east salt was not observed, only the dark surface of the Bunnee and the Kutch hills beyond it.

Gora Doongur.

The southern or Gora Doongur (white hill) range is much less lofty than the other and has a much narrower base. Like that to the north its most precipitous side faces also northwards, and this feature coincides with a belt of contortion in the rocks which terminates eastward in a bold anticlinal curve, which, forming high ground, may be seen from long distances.

All along this range calcareous sandstones, coarse or fine grained, with red fossiliferous layers, silicious and shaly olive beds, and hard shelly bands, (the fossils being all fragmentary,) may be found. On the crest of the hill and southern flanks more brownish and purple tints occur, and as the section ascends the beds become less calcareous, with highly ferruginous layers here and there.

Fossils are not numerous, but small echinoid spines and broken shells were observed in strong blue calcareous beds at the hills south

of Dorwar village. In the fragmentary shell bands badly preserved *Modiola* and *Melina* occur; in thick shaly bands numbers of *Corbulæ*, some *Terebratulæ*, large gray blocks of fossil wood, and from the strong beds which form the crest of the hill a few small scattered fish teeth were obtained. Many of the species from these places are identical with forms found among the lower beds in the islands to the east. *Nucula* flags occur near Undoo, and a few purple conglomeritic sandstones contain *Astarte*, *Modiolæ*, and oysters.

The whole of these marine fossil-bearing beds have been referred to the lower division of the Kutch jurassic rocks.

Margin of the island.

A margin of low ground of no great width, but narrowest where the mountains rise most steeply from the Runn, surrounds the Putchum isle. In this low ground, overlapping and wrapping round the jurassics on the west and south, are sheets of hæmatitic laterite, sometimes accompanied by its usually associated earthy rocks and beds resembling volcanic ash, the whole dipping from the higher ground at angles of 5° and less.

Sub-tertiary.

As usual, the unconformity of this group of laterite sub-tertiary rocks to those below is but slightly, if at all, apparent; but to the east of Kaora near Raimulrow hill foot, this group rests upon smooth gray gypseous shales with red bole and purplish layers belonging to the jurassic formation. There are also bands thickly studded with casts of bivalve shells of remarkably thin structure, together with fragments of planulate *Ammonites*. The dip of both rocks here is to the south-west, but as these shales are not always to be seen in the same position, and the lateritic group rests indifferently upon other rocks of jurassic age, the unconformity may be inferred.

Overlying the laterite north-west of Dinara is some rugged white kunkury rock without fossils, but at the village of Drobana, brown rusty

sands forming apparently the upper surfaces of the lateritic beds have concretionary lumps and layers containing *Turritella,* small bivalves, and fragments probably of *Echinanthus* (or some such depressed *Echinoderm*) which fix the tertiary age of the rocks. Northward of this near Koorun, and again east-north-east of Ruttria, the lateritic series (at the former locality containing some shales) is overlaid by thick white and yellow soft sands, also supposed to belong to the tertiary group, and sometimes containing fantastic calcareous concretions. A patch of red rocks occurs on the southern flanks of the Kala Doongur, not far from the village of Dhorawar, nearly in the centre of the Putchum, suggesting the possibility that the sub-tertiary group extended once throughout the valley across the island.

Littoral concrete.

A small patch of littoral concrete full of gastropodous and univalve shells on the northern shore of the Putchum has been already mentioned; it is but a few feet thick, and, if the fossils could be identified as recent, might bear testimony to the former submerged condition of the Runn. If not recent, they are probably very new tertiary. They are preserved only as casts.

A ruined temple on the road between Dinara and Kaora was said to have been thrown down by the earthquake of 1819, but nothing could be discovered from it as to the direction of the force which destroyed it.

KURREER.

The Kurreer Island shows a continuation of the northern Putchum range, but completely isolated from it by the Runn. The same features of ground, rising northwards in a long slope abruptly terminated by cliffs, again appear and the contorted zone at the northern foot of the Kala range is represented by a broken anticlinal curve, its axis nearly coinciding with the line of cliffs and its steep northerly inclinations being occasionally seen.

Fault?

The sharp crush along this anticlinal flexure may have been relieved by faulting parallel to, or partly coincident with, its axis; but this is obscure, the rugged detritus from the cliff concealing its foot, and all trace of the rocks to the northward being lost under the unbroken surface of the Runn.

Similarly to other anticlinals in Kutch this one has an undulating axis, depressions in which give the outer beds a tendency to fold over it at the ends of the island; while at the foot of the long southerly inclination, they commence to roll again, forming parts of minor anticlinal and synclinal curves.

The south slopes of the hills take their inclinations from those of the strata dipping in that direction at angles seldom higher than from 3° to 5°, and rising gradually up to heights of more than 500 feet.

Thickness.

Taking the height of the cliffs as nearly representing the thickness of the rocks, the section here may have a depth of 500 feet; for although a northerly dip is occasionally seen, all the bolder precipices exhibit only the apparently horizontal outcrops along the axial line.

Lowest beds.

The lowest beds seen beneath the cliffs are rugged and lumpy shales occurring as a thick band with highly fossiliferous layers containing numbers of *Corbula lyrata*, Sow., a fish tooth, and some other fossils.

Over these, and forming the more inaccessible portions, are thick bands of warm-coloured yellowish sandstone, sometimes containing quartzite pebbles and pieces of metamorphic rocks, and above all come harder, finer and more fossiliferous beds, very much resembling, but rather less calcareous than, those of the Putchum. These form all the long southern slopes, and contain numerous bivalves, including *Corbulæ*,

Southern slopes.

Rhynchonellæ, Terebratulæ, &c., some being crowded with narrow crinoid stems, showing plainly in white carbonate of lime upon hard yellow or red flaggy slabs. One zone near the crest of the ridge contains several small asteroid corals. The following names will indicate the kind of fossils obtained from this Kurreer portion of the range :—

Corbula pectinata, Sow., a *Cardium,* closely resembling *C. Buckmani,* Morris and Lycett; *Anatina,* closely allied to *A. plicatella,* Morris and Lycett; a *Radula* and a *Gervillea,* most probably identical with *R. duplicata* and *G. Waltoni* respectively. Of Gastropods may be noticed a species of *Nerinea,* one of *Natica,* closely allied to *N. pyramidata,* and two species of *Nerita,* very similar to *N. rugosa* and *N. Buvignieri;* these fossils are all from the lowest beds: while from the uppermost portion of the series seen here come a *Belemnite* like *B. Bessinus, Astarte compressa,* a *Trigonia,* probably *T. interlævigata, Cucullea virgata, Ostrea Marshii,* a *Rhynchonella* very like *concinna,* and several other forms.

Lower ground to south.

In the lower ground, the rocks overlying those just mentioned often contain black or red ferruginous bands with white salt efflorescence, some with the peculiar concretionary structure alluded to at page 115, and they usually consist of soft, white, yellowish or purple sandstone, obliquely laminated, and so incoherent in places that martins, &c., are able to burrow into it to build their nests. Shales and calcareous beds are still occasionally present and some conglomerates occur.

Cliffs.

Some of the cliffs on the north side of this island are very fine, giving an impression of greater height than that indicated by the aneroid barometer. Measured by this, the absolutely vertical portions may average about 100 feet and their summits 350 to 400 feet above the Runn. For more than 200 feet of this height they have a rugged steep talus, with occasional projecting crags, which sends out more gently sloping spurs northwards, and not unfrequently the naked rock appears down to the very edge of the Runn. (See Fig. 2).

Fig. 2.—Cliffs north side of Kurreer on the Runn of Kutch.

Coast.

In such situations, and often weathered, they can hardly be said to have much of the aspect of seacoast cliffs, but the very weathering so strongly apparent may have removed the traces of marine erosion; no old sea caves were observed, but in some situations the rocks were pierced by holes, such as have been supposed to be the burrows of mollusca, but these may just as probably be a form of weathering affecting calcareous segregations in the rock. They have not been found restricted to one level, marking the position of an old waterline.

Where the weathering of the rocks is excessive, such forms as these (Fig. 3) are common.

Fig. 3.—Kurreer—Rocks on edge of Runn, ? Seaworn, Mirage in distance.

Sub-nummulitic.

In Kurreer again, as in Putchum, the sub-nummulitic group of laterite and white earthy beds re-appears, resting on the flanks of the hills along the south-eastern side, the low dips nearly coinciding with those of the jurassic rocks below and carrying the group beneath the overlying alluvium. The laterites here are frequently very strong, giving a deep red color to the country through which they run. A section across their junction with the jurassic rocks as exposed at Junan has been given at page 72, and the method of the occurrence of the laterite and unctuous clay is illustrated in Fig. 1, page 69. At a little distance to the north-west of Junan, the junction is complicated by contortions and faults, and among the soapy amygdaloidal volcanic-ashy looking clays* are soft, earthy white sandstones; the laterites again as usual forming the uppermost part of the series which is visible.

Some few agates occur scattered over the lateritic surface east of Junan.

From Chapar to near Bamunla the junction often appears faulted, and a few outlying patches of the lateritic beds rest upon the jurassic rocks northwards of the latter village.

At the extreme north-west end of Kurreer, a mass of gray porphyritic trachyte, rising to between 300 and 400 feet, forms the little island in the Runn, called Bunjeera Doongur, surrounded by water, salt and mud. Its heavily rounded outline presents a strong contrast to the scarped hills of Kurreer and the distant slopes of the Putchum. It is reputed to have sheltered vessels in stormy weather when the Runn was a navigable sea. (Lieutenant Dodd).

The occurrence of this trap so nearly in line with the intrusions north of Putchum Peer and Mooanna hills suggests that the line of weakness through which they found their way was possibly one of continuous fracture.

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* Used as soap by the natives.

Scattered thickly over the ground near the bank of a river crossed by the road from Gudra to Junan, a patch of large broken univalve shells, *Potamides palustris*, was observed; whence they came could not be discovered, but their fragments were found in the neighbouring stream. They have been frequently found (often near rivers) collected in the same way all over the northern side of Kutch, and always in a fragmentary state as if brought together by human or animal agency. They have a very recent appearance, but were never found alive in the rivers. Their general distribution in small patches is to say the least peculiar.

The alluvium of Kurreer is of the ordinary brown loamy or sandy character, passing so indefinitely into or under the Runn that it is difficult to say where any divisional line exists between one and the other.

RUNN ISLETS.

In that portion of the Runn which separates Kurreer and Béla from the Wagur tract is a group of rocky islets; of these Gangta and Kakeendia Béts are the most lofty, the rest being low 'beyts' or 'beers.'*

Gangta and Kakeendia Béts.

Both of these hills rise to heights of 90 feet (aneroid) above the Runn, and both exhibit anticlinal curvature of the rocks, which, as the axis of the latter place shows a tendency to curve, may be parts of one contortion, both islands lying in the general direction which it takes. These islets would seem to mark a position at which oblique minor anticlinals occur in the wider curve formed by the approaching inclinations of the northern range and the Wagur rocks opposite to them.

KAKEENDIA BÉT.

In Kakeendia Bét, which is separated from Kurreer by a narrow belt of soft wet Runn incrusted with salt sometimes two inches thick, rocks

* The meaning of these words is somewhat obscure: 'beer' means a grassy place, and 'bét,' frequently applied to a cone or peak, is said in Captain Burton's 'Sinde, or the Unhappy Valley!' to mean a heap, or ground of that shape. As such, it is applicable to the islets above mentioned; but in other parts of the Runn, flat spots, sometimes called 'dhooi,' are also given the name of 'bét.'

very similar to those forming the long slopes of the range to the north are met with, much contorted and occasionally shifted by small faults. They dip north and south at angles so high as to approach the vertical, the highest dips being as usual to the north. They contain fossils similar to those found along the southern side of Kurreer, and in one bed near the summit a single fish tooth was found.

At a spot near the passage from Kurreer a spring issues which may account for the wet state of the Runn close by. Its water is said to be so saline as seriously to affect those drinking it, but the rushy ground about it seemed much trampled as if resorted to by cattle.

Gora Beer.

In Gora Beer, a low island, four or five miles to the southward of the last, are some nearly horizontal undulating thin beds of sandstone, hard, ferruginous, silicious, and some more friable, overlying nodular gypseous earthy beds with soft sandy portions. Where these dip at about 2° to the north on the southern shore of the island, they contain numerous *Belemnites*, some *Ammonite* fragments; and one very perfect valve of a large oyster with deeply notched margin allied to *O. Marshii* was found.

Gangta Bét.

In this island hard angular ferruginous rocks with thin shaly layers containing *Belemnites* were found to overlie dun-coloured calcareous fine grained rock, cut up into rectangular figures by hæmatitic bands. It also contained *Belemnites* and oysters and other shells. Below this, purple sandy and calcareous beds with concretionary earthy layers, also fossiliferous, occur, and underneath all, the bulk of the hill is formed of yellow calcareous, red ferruginous, and soft rubbly red, mottled and pale purple, sandstone. Just beneath an old tower on the summit of the hill, some of the red beds contain numbers of little *Rhynchonellæ*, small oysters, *Terebratulæ*, and *Trigoniæ*, little *Ammonites*, &c.; the assemblage being varied, but the sizes of all the fossils peculiarly minute.

At the south side of the island lying against the steeply sloping beds of the anticlinal with an apparently very high dip approaching to perpendicular are some soft gray and purplish gypsiferous shales overlaid by laterite. But little of these rocks is seen, and that little has the usual tendency to weather so as to conceal its bedding. Supposing the laterite, however, to represent the sub-nummulitic group, the steepness of the angle at which it appears to dip to the south is remarkable.*

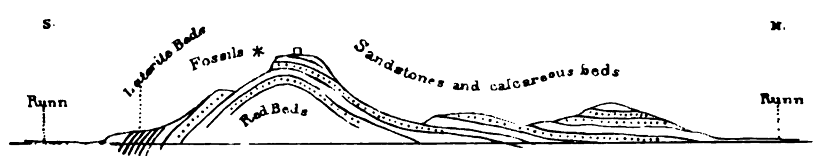


Fig. 4.—Sketch section over Gangta island.

Runn.

The Runn surrounding Gangta is in many places covered with salt, and to the south it was found so soft that it could not be ridden over; it is formed of fine brown or black silt which cracks on drying, the surface having frequently a soft blistered crust slightly raised by the crystallization of the salt which it contains.

There are some other flat 'beers' or 'béts' to the west which have no remarkable features.

BELA.

Béla.

This island is misrepresented upon some maps as joined to the northern side of the Wagur district; it is on the contrary separated by Runn, which may be, along the shores, of the nature of '*Laana*,' but is in places overlaid by

* Indicating that the contortion of the older rocks took place early in the tertiary period.

salt. The general arrangement of the rocks is quite the same as in Kurreer and Putchum, except that the general strike is deflected southwards at its eastern end, giving to the hills east of Béla town somewhat of an axial elongation in a north and south direction. The anticlinal axis, of which the range here forms the southern side, becomes so much depressed north-east of the town that a synclinal is formed across it, and a deep open gap occupied by alluvium intersects the range.

Lodranee.

In the neighbourhood of Lodranee at the west end of the island, the sub-nummulitic rocks rest upon the lower jurassic beds with the appearance of complete conformity usual at their junction along the range. The following section was observed to the eastward of the village :—

Dip south, 5°.

SUB-NUMMULITIC ...	5 Strong red laterite	30 feet.
	4 Sandy black variety of ditto	
	3 White clayey bed, in places sandy, with a hard quartzose layer	
JURASSIC ...	2 Very soft ferruginous and other sandstone, sometimes conglomeritic or gravelly and loose ...	10 feet.
	1 Soft crumbling sandstone, variegated red and white, with wood and plant fragments and a *Corbula*	

Flaggy, shaly and thick brown sandstone, some gypsum in the shales.

In this section it is difficult to fix a lower boundary for the lateritic series, as the beds under the white clayey stratum have a strong resemblance to some more intimately associated with the upper group in other places. The white rock, however, probably marks the lower limit as elsewhere.

Coming out from beneath the beds of the above section, northwards, are coarse nearly horizontal thick sandstones overlying harder and closer yellow calcareous rocks containing numerous fossils; lying usually in somewhat reddish partings. They are chiefly bivalves with some

fragments of wood, pentagonal crinoid stems ,spines of echinoderms rather numerous, and of three kinds, and a very deep form of oyster, &c. From the compact nature of the rock, those only which weather out are easy to obtain, and the general aspect of the fossils is quite the same as that generally to be observed on the southern slopes of this Runn island range.

North of Lodranee.

Rocks of the same kind sheet the surface until the edge of the cliff to the northward is reached. Here in one of the beds a number of casts of cylindrical and furrowed plants was found, and in some earthy rugged beds below, an assemblage of fossils similar to that already given, p. 105, (? Bathonien). Coarse sandstones underlie these, and beneath them whitish calcareous muddy beds with a few hard layers, then dark shales weathered greenish with bands of fossiliferous limestone; then more variegated shales, some of which are gypsiferous, overlying some 5 feet of buff, calcareous, glistening sandstone, with other shales beneath. A small trap dyke occurs near this place, and a spur composed of flaggy calcareous beds runs out from the cliff to the Runn, terminating in a peculiar hill covered with white altered-looking fragments of close grained apparently calcareous rock. Some ferruginous fragments and agates scattered about here indicate the probable existence in the neighbourhood of the sub-nummulitic group.

Neelua Hills.

The part of the range just eastward of this is called the Gora hills, and still further east goes by the name of the Neelua hills, where the highest summit on the range occurs, with an elevation (aneroid) of 617 feet above the Runn. Although from the greater height the section must be thicker, the same varieties of rock as are found near Lodranee only occur; massive light coloured sandstones forming the bluffs, and hard fine calcareous and fossiliferous beds the southern hill-slopes. At the crest of the hill some calcareous conglomeritic grits contain numerous metamorphic and

some syenitic pebbles, indicating an unconformity between the jurassic formation and the (probably next underlying) metamorphic rocks. Above these are some coarse, pale yellow and brownish sandstones with quartzose layers, succeeded and covered up by the sub-nummulitic group.

On the northern side of the Neelua hills the broken spurs from the cliffs sometimes show the northerly steep inclinations of the anticlinal, complicated by local contortions.

Peculiar mounds of sand.

On this side of the range, northward from the town of Béla, at a considerable elevation, the rocks are partially concealed by singular mounds of sand-like disintegrated or unconsolidated sub-recent concrete. This is very local and in places quite incoherent, but some portions possessing the ordinary concreted character also occur at the same place, patches of the latter resting on the surfaces of highly inclined jurassic beds, the stratification of the sub-recent rock abutting against the sloping surface on which it was deposited.

This sub-recent concrete occurs in many places in the glens of the island range under description; it is always irregular and inconstant, so recent-looking that it might even now be in process of formation. This actual formation has never been observed, while evidence is constantly afforded of its destruction by atmospheric forces, and its modern age is established by its containing calcined human bones at a cinerarium near Béla.

Lateritic group at Dourawa.

At a place called Dourawa to the westward of the town of Béla, a stream course exposes the junction between the jurassic and sub-nummulitic rocks. The aspect of the locality is peculiar, the broken ground and steep hillocks between ravines covered with laterite debris, having the most brilliantly contrasted tints of purple, bright red and rusty orange associated with intense

black and white. As the rapidly weathering detritus overruns the rock beneath, the larger streams only show the section which was noted as follows:—

General dip to south, low, undulating.

SUB-NUMMULITIC...	Black and red (ferruginous) laterite ... ... Red, white and yellow laterite breccia ... ... Ferruginous red shale ... ... White soft sandy mud in places mottled, in others having ferruginous layers	25 ft.

Unconformity not apparent.

JURASSIC ...	Thinly bedded white sandstone, hard, with ferruginous bands	5 ,,
	(This was found to contain small fragments of a narrow *Zamia-like* plant).	
	Brown soft sandstone with white specks ...	20 ,,

At a little distance to the east, the uppermost bed of the jurassic group, in contact there with laterite, is an altered-looking sandstone so silicious as to bear a close resemblance to quartzite, and southwards the sandstones of the same jurassic group roll up to the surface, overlaid by the laterite,—the shaly and other beds beneath it being there absent or less prominent.

Palæozamia.

The occurrence here of a small and fragmentary *palæozamia* in the jurassic beds is the only instance of the presence of these plants which has rewarded a close search all through the most easterly part of the province. It may be taken to indicate either the close of the marine period, or, with probably greater accuracy, an analogy to the case of the intercalation of terrestrial and marine organisms in the far western part of the district which has been already alluded to (p. 51).

Lava dykes.

Another unusual circumstance is, that the section above given is crossed by two dykes of soft purple lava, one of 28 inches, the other about 12 feet in width, this

being one of the few instances in which these red dykes have been observed associated with the lateritic group. Here they occur just at the junction crossing the lower beds and coming up to, but—so far as could be seen—not passing through, the laterite.

This, however, was removed for a little distance near one of them by denudation, and in another spot the section was confused by the rubbly weathered state of the surface and some slips or small faults.

Not far from this place a small section exposed three different arrangements of the ferruginous materials of the beds, the uppermost of which resembled that shown in Fig. 1, and contained imbedded agates; below this the white and more earthy clay had the ferruginous portion in horizontal laminations, while beneath all was a more solid and homogeneous bed.

Varieties of the lateritic beds.

In the stream which passes Béla the red laterite and white beds beneath are also to be seen.

On the flanks of Mooanna hill the same calcareous hard fossiliferous beds, as occur to the west, re-appear, with some of the peculiar compressed concretionary ferruginous bands so frequently noticed in the jurassic rocks (Fig. 5). Some purple beds, near, are full of obscure fucoid (?) markings, while from the flanks

Mooanna hill.

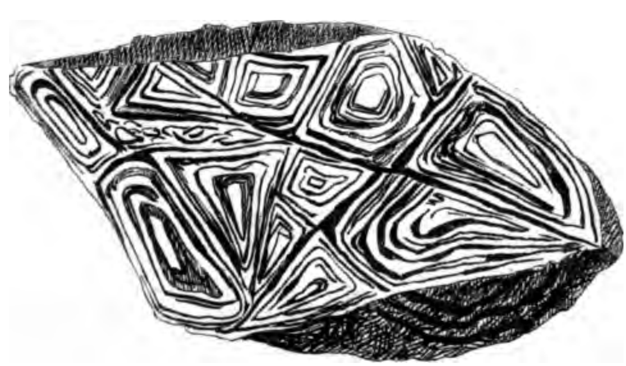


Fig. 5.—Block of concretionary ferruginous sandstone, about 2 ft. by 1 ft. in.

of this hill also were obtained several specimens of a *Pholadomya* probably identical with *P. Dunkeri*, Brauns., from the Bathonien beds of Hanover. A large species of *Modiola* also was common.

Near the summit of the hill the zone containing the small hexagonal and asteroid corals again occurs, while on the sides of the steep 'coomb' to the north numerous thick fallen slabs present on finely weathered surfaces crowds of *Corbulæ*, *Trigoniæ*, and other bivalves with some minute and delicately marked spiral shells.

Half way down the side of the 'coomb' the rocks are broken through, and cut up by intricate intrusions of solid, gray, spheroidal trap or trachy-dolerite.

In one or two places these traps have somewhat of a contemporaneous aspect, the jurassics resting upon a volcanic looking mud bed, red in colour, and this upon a similar, but black layer, which is in contact with rudely columnar basaltic trap below. It appears probable that this 'coomb' has been formed by the wearing away of a large irregular intrusion of trap, outliers of which project above the Runn just at its mouth.

Near Mooana village some purple and basaltic trap intrusions occur at the junction of the sub-nummulitic and jurassic rocks, one of which had a bedded or laminated appearance.

Although species of *Rhynchonella*, *Astarte*, and other fossils of the Béla country are more generally distributed than similar ones in the Wagur tract opposite, they are seldom found of such large size. One seems also here to have passed out of that portion of the jurassic formation characterised by the occurrence of *Ammonites*, but few even of their fragments having been met with.

Agates on lateritic grounds.

Over much of the lateritic ground, particularly in the neighbourhood of Béla, flints and agates are so numerous as sometimes to form a coarse gravelly layer on

the surface. Whence they have been derived originally is a matter of much uncertainty, the agate-containing traps not being present, but they have been found *in situ* in some places in the lateritic beds, and are very numerous in those already mentioned as exhibiting three kinds of lateritic structure south-west of Béla.

The alluvium of Béla is similar to that of Kurreer, and has no very marked peculiarity worth further notice.

CHORAR.

The continuation of the Runn Island range terminates eastward in Chorar, forming some hilly ground at the north side of the island, of no great elevation, perhaps not exceeding 150 feet.

Calcareous and shaly marine fossiliferous rocks with massive and flaggy tough sandstones of the Béla type occupy the north and western portions of the hills. The corals of the range seem here to reach their greatest development. Many were found weathered out on the top of the hills, but were usually so crystalline as to have almost lost their structure. Some dark red or purple bands are full of fragmentary shells, and from lower beds were obtained *Rhynchonella*, *Pecten*, or *Radula*, *Ostrea*, spines and plates of *Echinodermata*, segments of crinoid stems, &c., and, near the village of Eyware, a band crowded with *Corbulæ*.

Northern and western parts of hills.

The beds are contorted in places, but on the south side of the hills southerly dips predominate, and numerous intrusions and dykes of basaltic gray and purple trap occur.

Near the village of Charunka soft conglomeritic sandstone and shaly beds contain large blocks of fossil wood, one broken log of which measured 25 feet in length.

On the southern and eastern sides of the hills lateritic ground prevails, one hillock, 50 feet high, being entirely composed of laterite and black ferruginous sandstone.

Southern and eastern sides of hills.

South of Eyware is a scarp of these lateritic beds, at the base of which much decomposed trap with a laminated structure occurs. Interbedded with the laterite is a dull speckled sandstone underlying a layer of rich iron ore, above which white beds overlaid by laterite dip to the south-east. The low angle of dip carries these sub-nummulitic rocks over a wide space, but they are eventually lost sight of under the wide tract of alluvium which occupies most of Chorar.

Superficial deposits, south side of island.

On the south side of the island some of the superficial deposits, which might pass for alluvium, are believed to belong to one of the newer tertiary groups, and have been coloured accordingly, although from the absence of fossils the fact is somewhat doubtful. A little flat topped hillock in the Runn on the road from Peeprala to Adeysur presents the following section in natural order:—

Beds, horizontal, depth 30 feet.

TERTIARY ...	5. Hæmatitic black grit and yellow ferruginous sandstone, containing abundant fragments of wood and one of bone.
	4. Loose, dry, yellow, white and variegated sands passing downwards into—
	3. Mottled and variegated clays with layers and seams of transparent gypsum, some 2 inches thick.
	2. Argillo-arenaceous shale, also gypsiferous.
	1. Mottled clays, some parts alternating laminæ of clay and sand.

at Futtyghud, consisting of coarse felspathic white and variously banded sandstone and grit with some mud beds, and a parting of greenish yellow marl. The hill is traversed by intrusions and dykes of gray trap, and much of the country in the neighbourhood is occupied by sandy plains, where the rocks are seen rising above these to the east and north. They consist of coarse, open, gravelly sandstone, some of the beds hardened by infiltration of iron, assuming a black color on exposure. They are cut up by trap dykes, and by the very frequently observed silicious veins resembling the '*gangue*' or '*horse*' of a lode, sometimes termed by the Cornish miners '*ramps*.'

North-west side of tract.

Ramps.

About Doosulpoor, and to the east and west, nearly the same varieties of hard fine grained calcareous and somewhat flaggy beds as occur in Béla have northerly inclinations towards the Runn.

Doosulpoor.

Between Rev, or Row, and Rahpoor, is an outlying patch of the sub-nummulitic beds appearing from beneath the alluvium to the north, the jurassic rocks of the adjacent country being red ferruginous and light colored sandstones interstratified with gray shales; these undulate over the country, and the sandstones contain a few *Ammonites* and other fossils.

Rev.

From Rahpoor to Oomia, and around the former town, ferruginous sandstones and earthy shales, strong yellow sandstones and red and light-colored flags and hæmatitic beds, undulate or dip north at 5° to 7°, and are crossed by a long dyke of purple lava-trap. Hence to Adeysur, the rocks have more the aspect of those belonging to the upper jurassic group and are much intersected by dykes and 'ramps,' particularly in the vicinity of the latter town. Hereabouts the beds slope generally towards the alluvium, which is bordered by an intervening band of the lateritic and white sub-nummulitic rocks.

Rahpoor to Oomia.

Adeysur.

Southward of Adeysur, the same varieties occur, and in a mound of gypseous clay and shale, associated with the lateritic and white beds, three miles east of Paraswa or (Palauswa), a quantity of fossil wood was found, one fine log measuring 3 feet 9 inches in length. The position of these clays is rather uncertain. On the right bank of the Paraswa stream, west of the village, the following section in the lateritic bed was noted:—

	Dip N. 30°; W. 20°.	Ft.	In.
SUB-NUMMULITIC.	4.—Ferruginous and white chalky beds with lateritic bands ...	40	0
	3.—Deep red lateritic beds, the upper part most highly ferruginous	30	0
	2.—Muddy light colored and shaly clays	12	0
UPPER JURASSIC.	1.—Highly ferruginous dark purple sandstones rapidly decomposing, variously colored, saline, banded nodular and hæmatitic	20	0

About a quarter of a mile further down the stream a different set of rocks occurs resting *unconformably* upon the denuded surface of the jurassic beds and dipping gently to the south-west. They consist of hard calcareous, overlying finely laminated, sandstone spangled by minute micaceous specks, with which are some reddish clays. In one place the section is—

		Ft.	In.
TERTIARY ...	Hard calcareous sandstone	3	0
	Softer gravelly conglomerate	3	6
	Pale clays not well seen.		

In the upper beds, a band, 12 to 14 inches thick, just above the conglomerate, is full of very perfect casts, both external and internal, of a spiral shell, apparently a species of *Cerithium*, the casts bearing the impressions of nodes or blunt spines on the outer sides of the whorls. In the conglomerate are pebbles of ferruginous lateritic rock, fragments of ferruginous clay, and sandstone polished lateritic gravel, all embedded in a fine gray sandy cement. The conglomerate thins out, and the fossil bed disappears altogether, the whole patch having a very limited extent.

SECTION 3.—WAGUR, E. KUTCH.

The strata of Wagur have at a glance a sort of circular or oval arrangement, their dips carrying them at all points beneath the alluvial plains and low ground or Runn which, whether broad or narrow, everywhere forms the margin of this parganna.

Sub-nummulitic.

The outward beds in many spots are detached representatives of the sub-nummulitic group with its constant laterites, gypseous shales, and white earthy rock. In one or two places outlying patches of these beds occur, and the small representatives of them edging parts of the shore on the Béla side are crowded with agates weathered out, and lying thickly spread over the surface. The underlying white beds are absent here.

It has been already observed that in the extreme west portion of the district, much difficulty was found in separating these sub-nummulitic rocks from the jurassics. Here at the opposite end of the province the same difficulty recurs, particularly where red ferruginous or gypseous jurassic beds underlie, with every appearance of conformity, rocks which from their strikingly characteristic aspect, have been unhesitatingly placed in the higher group.

Fault west of Kuntkote.

In one place at the western side of the Wagur tract, west of Kuntkote, these lateritic beds are brought against the jurassics by a fault along which the upper rocks have frequently a deep brownish red colour and a texture identical with that of ordinary quartzite except for the occurrence of some grains of quartz in the highly silicious matrix. Similar silicious beds occur in several parts of the district both in these and among the jurassic rocks. Their origin is obscure, but their metamorphic nature is more than probable, seeing that they are in numerous cases more or less closely

associated with igneous intrusions or lines of fault or fissure through which steam at a high temperature may have penetrated.

Jurassic.

Within the positions occupied by the lateritic series, the jurassic rocks undulate with many irregularities and occasionally high dips over the country, rarely rising into high hills, dipping round their exposure generally outwards, and presenting in almost every view long lines of outcrop gradually dying out; their prominence giving place to that of others, or suddenly ending in small abrupt cliffs. An anticlinal axis, or more than one, passes in an east and west direction near Adhove, Chitrore, and Kaumeer, but the contortions being complicated by curvature of their axes, interruptions in their strike, and local occurrence of minor curves, the anticlinal becomes too confused to form a strongly marked feature of the ground.

All over this Wagur portion of the district the jurassic rocks present a complex aspect, in places resembling the lower beds, in others the coarse upper ones, while in many localities, beds, most like those occupying an intermediate position, have intercalated bands containing marine fossils.

There being no definite arrangement traceable which would place these beds in an ascending series corresponding to that elsewhere seen, they have been supposed to change laterally, so as to present in their vertical order a wider transition from the lower to the upper characteristics, and one more than usually marked by the presence of marine fossiliferous beds. In some localities, however, there is a prevalence of the coarse white sandstones typical of the upper group in which, notwithstanding close search, none of the *Palæozamiæ* or other plants have been discovered, nor any marine forms either. In the absence of fossil evidence, these have on petrological grounds been included in and mapped as belonging to the upper sub-division.

At the north-west side of the tract the ground has no great elevation, its surface showing long level lines broken only by an abrupt hill

the upper portion of the section to the east. To the east of Chitrore are red variegated sandstones and shales, and gray and brown shales alternating with red yellow and gray flags full of small plant fragments. In the gray shales a few obscure shells (*? Cucullea* or *Amphidesma*), were observed, and among pale red flaggy sandstone and red flags, olive when weathered, associated with coarse purplish granular sandstone, some fragments of *Ammonites* and timber were found.

Similar rocks with perhaps more sandy shales occupy the country from this to Rahpoor with here and there fantastic masses of soft ferruginous yellow sandstone full of harder veins. A long dyke of dark basaltic trap crosses the country north of Chitrore, striking towards Badurgud, and is probably continuous with one observed near Kuntkote. At the village of Syee are some peculiar projecting masses of silicious hæmatitic sandstone weathering into large grotesque spheroidal forms.

Vittrooe hill.

The conical hill of Vittrooe with an elevation of 270 feet (above its immediate base, by aneroid,) is the most conspicuous feature in this part of the country. It is chiefly composed of thick, soft sandstone resting upon some 50 feet of shales and sandy flags and capped by massive white silicious indurated and largely columnar beds, the material of which has a striking resemblance to metamorphic quartzite. The same rock also caps Suttorea hill to the east.

From Vittrooe hill a set of basaltic decomposed trap dykes passes through the country to the northwards, traversing soft, yellowish and red sandstones, which occasionally contain a few *Ammonites*, *Belemnites*, and bivalve shells, some layers of the peculiar compressed concretionary ferruginous rock before mentioned (p. 115), and one of shelly limestone, also occurring in the country north of the hill.

Badurgud.

About Badurgud are soft, brown sandstones, generally overlying flags and light colored shales. They undulate at low angles and contain some fragmentary and imperfect fossils, including *Ammonites*, bivalve shells, crinoid segments,

Belemnites and wood. Westward of the village are several intrusions of gray trap often decomposed, some of which have penetrated between the neighbouring beds. A little to the south is the continuation of the large dyke, more than 100 feet wide, which has been already mentioned as occurring north of Chitrore.

West of Rahpoor.

Westward of Rahpoor, thick beds of yellow and soft red sandstone roll over the ground with low northerly dips, and on the road to Trummo some calcareous blocks full of *Trigonia, Astarte, Belemnites,* and Oysters, are scattered about. Where the road approaches a river said to come from near Adhove, reddish slightly ferruginous sandstone with some fossil wood alternates twice with soft purple sand, all horizontally overlying a thick band, somewhat more argillaceous, with calcareous nodules, in which are embedded numerous *Belemnites* and Oysters.

A thin dyke of purple trap crosses these beds in the river, and, further west, purple shales come out from beneath them, extending for a considerable distance down the stream. Where this turns to the north, and is crossed by the road to Trummo, these shales are overlaid by purple, red, gray, and brown sandy flags, with black and gray gypseous shaly and sandy partings, containing, as usual, small plant fragments and also little bivalve shells, the sandy beds having surfaces covered with *annelid* markings. Over these are red hæmatitic layers with yellow calcareous concretions and thin red shales, among which is a dim colored layer of impure limestone with a few shell casts. Five feet or more of red shales succeed, and then the same concretionary fossiliferous bed as was found further up the stream. At a little distance above this last bed both *Belemnites* and *Ammonites* occur in concretions in very dark red sandstones, among which one or two thick beds are crowded with large *Ammonites* and fossil wood so thickly entangled that it is almost impossible to extract an unbroken specimen from the soft ferruginous matrix. Some of the *Ammonites* here have a diameter of more

Kaumeer.

In the neighbourhood of Kaumeer the termination of the anticlinal already alluded to extends into the Runn, having on the north low ground flooded by the monsoon rains. A slight rising ground at some distance out in the Runn called Merduk in its strike may show a continuation of the axis. Along the axis south-east of Kaumeer are several trap intrusions, some of which show a laminated structure.

Northwards of Gorassey tank the following section occurs :—

Dip S. 25°; W. 55°.

	Descending order.	Ft.	In.
TERTIARY OR SUB-NUMMULITIC.	23.—From the alluvial plain northwards, loose and partly cemented yellow sand, calcareous, concretionary at base, and coarse. The granules and gravel highly polished, and the base white ... ... about	20	0
	22.—Mud colored muds and clays	12	0
	21.—Crumpled, mottled, shaly clays with a few thin veins of gypsum, upper part friable, color red and bluish white	30	0
SUB-NUMMULITIC	20.—Blank	65	1
	19.—Soft sandy yellow rock with some ferruginous gravel (not well seen)	33	0
	18.—Pale arenaceous clays faintly mottled, uppermost 2 feet of laterite ... ... about	20 25	0 0
	17.—Thick bed of laterite with white sandy interstices ...	20	0
	16.—Pale arenaceous clays (not well seen)	18 20	0 0
UPPER GROUP OF JURASSIC.	15.—Irregularly bedded dark, soft, sandstone made up of black and white sand	0	6
	14.—Finely mottled purple and white steatitic sands, also coarsely mottled, pale, pink, and streaky. Lower part laminated and argillaceous, with a parting of coarse, red, ferruginous sand, some of it white and silty ...	30	0
	13.—Light colored sandstones, soft, fine, open, lavender and purplish speckled with white	4	0
	12.—Very finely laminated soapy mud beds, silty and streaky, with minute flakes of silvery mica. A band in this of silicious gravel with steatitic matrix; other parts below more or less sandy	16	0
	Carried over ...	268-7 to 275-7	

		ft.	in.
	Brought forward ...	268·7 to 275·7	
UPPER GROUP OF JURASSIC,—(*contd*).	11.—Similar rock, but not so finely laminated, more or less arenaceous, mottled, concretionary. Lower part lateritic over dark purple sandstone	6	0
	10.—Thick beds of brown sandstone, earthy and streaked, or speckled with white variously colored pinkish brown parts; lower lavender colored; last foot or two fine conglomerate	100	0
	9.—Parting, yellow and red ochre and white chalky ...	1	0
	8.—Pale, soft, mottled lateritic beds with ferruginous and white steatitic bands streaked with purple, some sandy	25	0
	7.—Fine purplish open sandstone white specks ...	4	0
	6.—Soft beds, fine, pale, purple streaky, lower part thinly laminated and argillaceous	8	0
	5.—White steatitic gritty sandstone, no lamination, contains cylindrical ferruginous concretions	3	0
	4.—Ferruginous impure sandstone weathers honey-combed	2	6
	2.—Light colored fine gritty and steatitic sandstone without lamination, yellow concretionary ramifications .	7	0
	1.—Earthy open sandstone streaked and speckled with white	10	0
	Here a dyke of pale lavender colored lava-like trap and a ferruginous vein (4 feet) cuts through the section; crumpled and disturbed whitish mud or silt beds occur beyond the dyke.		
	Total thickness ...	418 to 452 ft.	

The lower beds of the above section are taken to belong to the upper jurassic group of Kutch. There seems to be a fault at the dyke as the white beds beyond it dip to south 10° east. The beds to the north are similar to those above described, and are either horizontal or undulate.

Chitrore.

About Chitrore the rocks are much exposed. The town itself stands on a thick escarpment of sandstone with a northerly dip of from 2° to 50°. Beneath these are thick, soft, white, shaly and sandy beds, red ferruginous, purple and variegated sandstone and flags and soft pale shaly beds. All these turn over and dip to the south, their inclinations just near the edge of the alluvium in that direction being very steep and sometimes quite vertical. Some higher beds seen here, which are particularly red and white, resemble

than 9 inches, and include *A. fissus* and some other species belonging to *Stephanoceras* and *Perisphinctes* (Waagen) indicating lower Oxfordian types. Fragments of the woody plants measured 2 inches across and more than a foot in length. Overlying these beds are calcareous sandstones and white arenaceous bands of limestone having the same general dip as the whole section, *i. e.*, to the northwards at about 3°, and showing themselves for half a mile or so still further down the stream. Just to the west of this fossil locality, the dip changes suddenly to the west at 25°, and the beds abut against a mass of trap ranging north and south some two hundred yards or more in width. Within this space are several varieties of basaltic, dark, greenish-gray, olive, pale-gray, crystalline and soft decomposing trap.

Trummo.

Between this intrusion and the village of Trummo an abrupt hill of no great height is composed of white sandstone nearly horizontal with two zones of massive gray and bluish quartzite closely resembling that of Vittrooe hill, the results probably of contact with the trap at the time of its intrusion. South-west of this hill the northerly dip again prevails, and beds of hard, fine red, yellow, and variegated grit contain numbers of *Nucula cuneiformis*, *Trigoniæ*, *Gervillea*, *Ostrea*, *Gryphæa*, and traces of *Ammonites*.

North slopes of hills.

Westward from this to the termination of the hilly ground near Chobaree, the hills present long and gentle slopes passing away beneath the Runn and low alluvial margin of the district, the beds dipping with the ground at angles of 2°, 3°, or 5°, and forming in the vicinity of Kuntkote and Kagnora, and thence to near Munfurra, a broken, but strongly marked, escarpment. The aspect of the ground, and also of the rocks, consisting of hard, close-grained light colored sandstones or grits, calcareous in places, unite to produce a strong general resemblance to the Kurreer portion of the Runn Island chain. Shales occur, but not frequently, except below the

escarpment, and some of the beds are conglomeritic. Many of the hard beds are highly fossiliferous, containing numbers of *Astarte major*, large *Gervillea*, n. sp., *Trigonia Smeei*, *Gryphæa*, *Pleurotomariæ*, &c., &c.

Iddurghur.

At Iddurghur, on the crest of the scarp, numbers of these fossils, the bivalves being in a fine state of preservation, strew the summit and sides of the hill. In many cases both valves remained together, and some single ones were beautifully weathered out, showing the clean surface and muscular impressions of the inside of the shell. The same fossils occur again on the northern slopes of the hills, but the large *Gervillea*, several inches in length, just now mentioned, which occurs with them, could never be obtained perfect.

Above the strata which form the long northern slopes here are yellowish and greenish-gray shales in bands of from 10 to 35 feet, with hard flaggy layers coming on, as they pass into the low ground; red ferruginous beds also occur containing fossil-wood and strong widely ribbed *Ammonites* of the same species as those at Trummo, but some light colored sandstones near them appear unfossiliferous. A coarse calcareous conglomerate above these contains a large, narrowly ribbed *Astarte*, &c., and a ferruginous bed above has *Belemnites*, and large ill-preserved bivalve shells. A thick group of shales and flags succeeds these, separated by a boley layer from some 50 feet of variegated red and white sandstone, which passes under soft, white, half compacted sandstone, a three foot bed of bole, and some dry rusty sandstone, with white blotches and patches of quartzose gravelly nature. All these with various northerly dips may be seen in the Saynar nuddy near Burrooria.

Dorawa river course.

In the Dorawa nuddy, a stream course next but one east of Burrooria, and in the neighbouring low country, red and yellow thin-bedded sandstones with numerous bands of shale are either horizontal or dip slightly to the north.

The same sorts of ferruginous beds as occur near Burrooria contain large bivalve shells and *Ammonites,* and in more shaly beds above these are *Trigoniæ,* a small *Alaria,* a large flat bivalve, four inches across *(? Astarte),* some *Gryphæa,* and through these and the ferruginous red beds scattered fragments of *Reptilian* bones. These being generally in a bad state of preservation were not determinable. The anterior extremity of the lower jaw of a *Crocodilian* with nine of the tooth-cavities remaining was found among the stones in the Dorawa stream, and comparing its mottled ferruginous matrix with the rocks in the banks for some distance above the spot led so far to something like an identification of its original bed, that other small and obscure fragments of bone were found, but it was impossible to say from what spot this rolled fragment came, nor could any other portions of the same skull be discovered.

These bone-containing beds rest upon alternations of white yellowish and pale red ferruginous sandstone, some slightly calcareous, and thick, soft purplish beds with harder lumps standing out from their weathered surface, all dipping to the north-north-west.

Overlying these with a low dip to the northward are the white and lateritic beds of the sub-nummulitic group, appearing, as usual, at the edge of the alluvium, their unconformity not being apparent here.

Kurkooe to Chobaree.

In a nullah near the road from Kurkooe to Chobaree thin reddish sandstones separated by shale partings rest upon dark-gray felted looking shale with obscure plant fragments and minute bivalve shells, in hæmatitic or boley layers of deep red colour. The laminæ of the shales are marked by bright yellow films and the red beds have saline efflorescences; the lowest beds of all containing much gypsum.

To the east of Chobaree the beds are somewhat contorted near the base of hills, forming synclinals, with short axes having east and west directions.

The following succession was observed here:—

General dip to west.

SUB-NUMMULITIC.

9.—Ferruginous and lateritic beds.

8.—Soft white and sandy ditto.

7.—Thin flags and shales.

6.—Orange red and brownish sandstones, 50 feet.

5.—Thin red flaggy sandstones.

4.—Pale yellow beds, thicker and more smooth, slightly calcareous, soft yellow clay and shale layers; these contain *Trigoniæ*.

3.—Red and yellow coarse and fine calcareous beds, full of large *Astarte major*, *&c.*, *Trigonia Smeei*, *Gervillia* and some fossil wood.

2.—Coarse red sandstone.

1.—Yellow, shaly, and rugged sandstones (beds of Iddurghur scarp apparently).

Reptilian bones.

In a red ferruginous conglomerate resting upon a bed of red bole and underlying a thin band of the concretionary rock figured at p. 115, (all three overlying those marked 3 and 4 above, but at some distance from that locality,) part of a large *crocodilian* bone, 8 inches in length, with a few other fragments near it, were obtained. These and the part of a skull from beyond Burrooria already mentioned are almost the only reptilian remains that have been met with in the jurassic beds of Kutch.

Below Iddurghur.

From the highly fossiliferous beds of the Iddurghur escarpment downwards the succession is this—

5.—A thin, red, sandy band with traces of *Ammonites* and *Ostrea Marshii*.

4.—Hard calcareous grits full of small sub-angular pebbles of quartz, in parts quite gravelly.

3.—Ragged, earthy, and fine yellow and gray calcareous gritty beds.
Fossils here become numerous, and include *Gervillia*, *Astarte*, *Gryphæa*, and *Belemnites*.

2.—Strong light coloured sandstones and flaggy purple and brown sandstones, some of which contain numerous straight striated plant fragments.

1.—Slightly calcareous whitish sandstones and gnarled ferruginous beds, with gravelly and sandy layers full of shell fragments.

From Kukrooa a low range of rocky sandstone hills runs to the westward parallel to the escarpment of the above rocks and coinciding with a fault which brings these against the lateritic sub-nummulitic rocks. Along this line highly silicious beds much resembling "fault-rock" occur in a generally vertical position undulating along their east and west strike.

Faulted sub-nummulitic beds.

South of the fault the red and white lateritic group overlies coarse gravelly sandstones and soft white clayey beds, quartzose conglomerates, concretionary hæmatitic bands, with some shales and flagstones, full of plant fragments. They are sometimes ripple marked, and a few exhibit *Annelide* tracks. The hard thick sandstones possess a concretionary structure, and the beds have a general low dip to the northward. They present little variety until some sandstone beds to the south-east of Mhow are found to contain the same large *Astarte* and *Trigoniæ* as occur at Iddurghur. Somewhat south of this they all turn over the ill defined anticlinal axis which passes along the south side of the hilly part of Wagur and dips at high angles southwards, descending abruptly beneath the wide alluvial plain, which forms one of the few fertile tracts of the province.

In the low country about Mhow sandstones, shales, and flaggy beds similar to those just now described undulate at low angles or dip to the westward; while directly to the north where the Kukrooa fault becomes no longer traceable, near Munfurra, the following junction with the sub-nummulitic band is seen :—

Mhow East and Kukrooa.

	Dip vertical or high to westward.	Ft.	In.
SUB-NUMMULITIC.	6.—Lateritic debris, bedding of the rock obscured beneath it, but probably nearly horizontal		
	5.—White chalky sandstone and gypseous shales ...	50	0
LOWER GROUP OF JURASSIC.	4.—Rubbly ferruginous sandstone	30	0
	3.—Hard red sandstone	3	0
	2.—Greenish yellow flags	25	0
	1.—Strong gray grits		

Country to the eastward of Mhow, &c.

Eastward of the country, the rocks of which have been just now described, the continuation of the Iddurghur escarpment near Kuntkote exposes from 100 to 150 feet of thick, coarse, and flaggy sandstone, resting upon some 50 feet of gray shales, with yellow partings and strings of gypsum, the shales containing small plant fragments, and the other beds a few imperfect bivalves and belemnites. Other yellowish and red sandstones come out from beneath these and undulate over the country, frequently alternating with gray shales and soft red sandstone bands enclosing *Belemnites* and numerous *Ammonites*, some of the *Perisphynctes* type being most common. With these are also two or three species of oyster, while some silicious beds harder than usual contain *Astarte* and *Cucullea*, &c., which are nearly impossible to get out of the rock.

Trap dyke.

North by east of Kuntkote are some intrusions of gray trap, a strong dyke of which becoming wider extends for two or three miles to the east-south-east, as if to join that occurring at Badurghud.

In the direction of Adhooe white sandstones appear more frequently among the red ones associated with purple shales and some harder bands. Just at the town ferruginous, ripple-marked, calcareous, and soft white sandstones form an anticlinal curve, the beds to the south, as usual, along this line of disturbance dipping at high angles in that direction, if not vertical, while those to the north have lower inclinations.

Fossiliferous beds.

At the northern base of the ridge here formed by the contortion, a calcareous conglomeritic bed was traced for a long distance near the road from this to Chitrore. Its fossils are numerous, but difficult to separate from the matrix; they include *Astarte*, *Belemnites*, of somewhat lanceolate form in section, *Gervillia*, 8 inches in length, a large corrugated oyster, *O. Marshii?* *O. deltoidea*, a *Cucullea*, a finely striated *Pecten?* and a coarsely ribbed *Ammonite*; also *Trigonia Smeei*, a *Trigonia* very like *T. truncata*, a *Veniella*, n. sp., and some other undetermined forms.

On the south side of the contortion above the sandstones forming the centre of the curve are hard calcareous rocks against which rests a quantity of soft calcareous and sandy white clay the bedding of which is very difficult to detect, though somewhat harder portions seem to align themselves parallel to the nearly vertical beds close by. This rock, if vertical, must have a thickness of nearly 100 yards, which does not reappear at the north side of the curve; it is therefore more likely that this marly deposit belongs to a later period, and in the absence of the laterites it may represent some of the unconformable tertiary rocks.

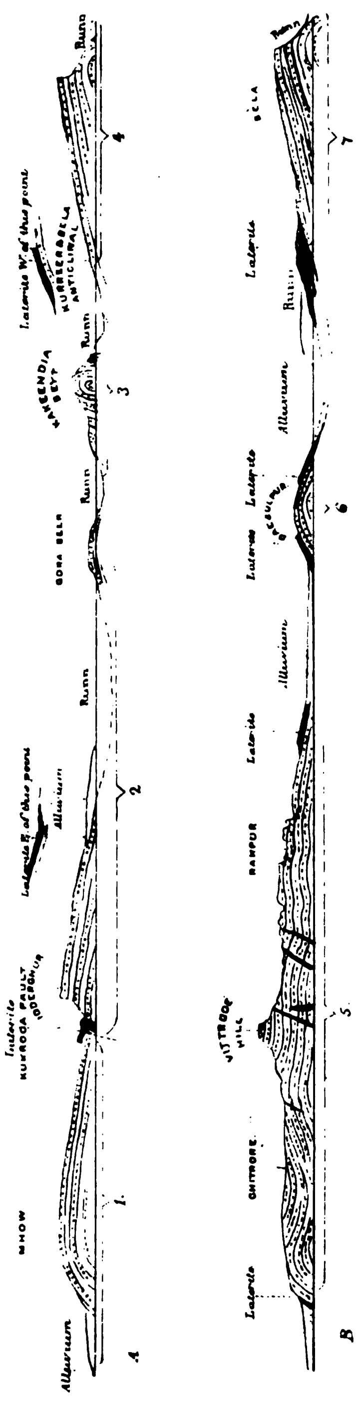


Fig. 7.—Sketch sections (A) across the west of Wagur. 7, B, across Wagur and Béla.

Adhooe to Badurghud.

Similar sandstones and shales with ferruginous beds undulate over the country north of the anticlinal between Adhooe and Badurghud, the fossiliferous band of Adhooe reappearing south-west of Wassitooa on the south side of the contortion and nearer that village, with dips which would indicate either a fault or sharp double bend along the line of strike.

Wamka.

A little patch of limestone which occurs at the outer base of the hills near Wamka, west of Adhooe, is believed to be of tertiary age, but is so isolated and so small that its relations become exceedingly obscure. It is crystalline, compact, and brittle, and contains faint traces of gastropods.

Alluvium.

The wide alluvial plain which occupies so much of the southern side of Wagur and separates its hilly ground from the rest of Kutch is, as usual, traversed by deep nullahs, and presents no peculiarity requiring special notice, excepting that the surface sometimes has a tendency to approach the nature of Regur. The alluvium is of the usual fine brown, loamy, and kunkury kinds.

SECTION 4.—NEIGHBORHOOD OF BUCHAOO AND THENCE TO LETTERA HILL.

Crossing the alluvial plain from Wagur the country is found to have a very different aspect. The jurassic rocks are all varieties of the coarse, white, gravelly, and soft sandstones of the upper group; and a broken chain of hills, extending in an east and west direction for about 20 miles, presenting steep slopes to the north and longer ones to the south, has its summits capped, or is sheeted along its southern side by flows belonging to the stratified traps.

Buchaoo and Vond scarp.

The scarp is best marked between Buchaoo and Vond, becoming broken to the west. Here the traps attain a considerable thickness towards the lower part of the southern slope, and several flows are observable; some are decomposed, rotten, and ashy, in parts amygdaloidal, others more massive and compact.

Intertrappean beds.

Among them a band of conglomerate with quartz pebbles is interstratified, and near it some soft sandstone changing from white to red is similarly situated. (North-east of Pussoora a thin layer of indurated white grit is also interstratified with the traps). These are not traceable for any distance and are unfossiliferous.

The lowest flow—forming the crest of the scarp—a fine grained basalt rests on some beds of very unusual occurrence, conforming to the traps, but apparently unconformably succeeding the jurassic beds; these peculiar rocks, although differing in character, are found in the place frequently occupied by the infra-trappean grits.—[F. F.]

The following section from Mr. Fedden's note book shows the structure of the western part of the escarpment:—

	Scarp about 180 *feet high (descending order).*	Ft.
	8.—Trap, fine grained basalt	1 to 6
? INFRA-TRAPPEAN BEDS, Dip S. 30° W. angle 15° to 20.°	7.—Brecciated and conglomeritic bed, lower part almost wholly of pink lava ?	3
	6.—Yellow sandstone	2 to 0
	5.—Conglomeritic and concretionary bed of pale lavender and pink lava (?) with large pebbles of hornstone, fragments of yellow clay and fine sandstone ...	1 to 4
	4.—Hard yellow and pinkish gritty sandstone ..	5 to 0
UPPER GROUP OF JURASSIC.	3.—White felspathic gravel of rolled quartz	? 7
	2.—White, sandy, and gravelly beds, upper part coarser, quartz gravel in a soft felspathic matrix, chalky lumps of which also occur.	
	(Scarp ceases at edge of plain).	
	1.—Sandy felspathic beds of great thickness, white mottled and pale pinkish or dove color, parts coarser, with seams of quartz gravel.	

One or two isolated lumps of the purple lava (?) were also found in the yellow gritty sandstone No. 4 of the above section.

Along the strike to the east this yellow sandstone disappears, and the brecciated part with large pebbles of hornstone rests directly on the white quartzose gravelly beds of the jurassic group.

Buchaoo.

The hard yellow grit is, however, persistent to the westward, having near Buchaoo fort but a thin capping of trap. Here the whole of the scarp is occupied by strong, ferruginous, gravelly and sandstone beds, while the wells in the plain at the foot of the scarp pass through the white felspathic beds of the upper group of the jurassic rocks.

Hills west of Buchaoo.

West of Buchaoo the ground is much broken and the succession is not so easily traced, though similar, but more varied, rocks underlie the traps. The same fine-grained basaltic flow extending in this direction occupies the upper part and southern slope of the hill west of the town; but the rugged hills just beyond and north of Chaprooa show only remnants of it.

The hard gritty sandstone, No. 4 in the section, is seen just below the trap, with only a parting of brown hæmatitic claystone. The soft yellow sandstones and gravels below are highly ferruginous, passing upward into black hæmatitic grit and conglomerate; the grit consisting of angular grains of quartz and felspar imbedded in an amorphous paste of limonite.

At the northern base of the scarp is a coarse conglomerate band with large smooth pebbles of opaque white quartz, probably a portion of the upper jurassic sandstones.

Iron ore.

Some of the ferruginous beds in the upper part of these hills have drusy cavities, containing pure hæmatite in botryoidal concretions. This ore was smelted formerly in the neighboring villages and at Buchaoo, but of late years the manufacture of iron has been given up owing to the scarcity of fuel and the facility with which the imported metal can be obtained.

Lateritic beds.

The lateritic beds of the sub-nummulitic group are frequently found along the southern side of the range immediately succeeding the traps. They are in places pseudo-conglomeritic and very volcanic-looking.

Loonwa.

At the village of Loonwa the red mottled argillaceous variety attains a considerable thickness, for a well is sunk in it to a depth of 45 feet.

In the stream cliff north of the village a vertical section exposes some of the white and faintly mottled, sandy upper jurassic beds, with a visible thickness of 50 feet. Their deposition is very irregular and oblique. Above these is the black hæmatitic bed with angular cavities and grains of quartz. The upper part of this rock here also passes up into conglomerate.

On higher ground the yellow gritty sandstone is found in its usual place beneath a capping of the grey basaltic trap.

West of Loonwa.

A strange assemblage of many colored volcanic-looking rocks occurs to the west of Loonwa. These are distinctly faulted at one place, abutting against the traps. On the south side of this fault the trap is succeeded by thick pseudo-conglomeritic and concretionary laterite. On the north side the rocks are varied,—purple, dark, and red lavas, volcanic dust and breccias; some are very ferruginous and cindery looking.

This accumulation presents no arrangement, in consequence of which and the occurrence of faults, its relation to the other rocks is obscure.—(F. F.)

Lettera hill.

At the western end of this chain of hills is a heavily rounded somewhat dome-shaped elevation called Lettera, composed almost entirely of dark greyish and black compact basalt. Lines of flow or bedding are difficult to find, but the whole mass has a southerly inclination.

In this direction it is overlaid by the lateritic or sub-nummulitic group, which also appears at its western end. At a little distance further to the westward, masses of pseudo-brecciated red and black hæmatite, full 50 feet in height, are associated with decomposing sub-columnar and concretionary trap at nearly the same elevation, these being probably brought together by a fault.

Approaching the western end of the hills from Doodaee, the jurassic rocks are seen to be succeeded by undulating beds of ferruginous or lateritic breccia, with a low south-westerly dip of 5°. These beds occur on slightly rising ground, are scoriaceous and volcanic-looking, enclosing blocks of deep red and purple hæmatite; upon them rests a thick bed of concretionary many coloured ashy rocks, some of the concretions being 3 feet 6 inches wide, with ferruginous concentric markings, and divided from each other by coatings of hæmatite. The hæmatitic masses

just now mentioned occur close by, but their stratification, if they possess any, could not be traced.

Volcanic lateritic rocks.

The arrangement of the lateritic rocks here is very obscure and peculiar; they are just of the same general aspect as the volcanic-looking beds of the sub-nummulitic group. Like them, too, they are associated with traps undistinguishable from the stratified trap group, and on one side of the range of hills appear to succeed these in their usual order, while on the other, they have strongly the appearance of being *overlaid* by the traps of this neighborhood; faults also seem to add to the obscurity of the locality.

It is quite possible that some of the unstratified red volcanic-looking rocks may have been extruded here, while there is certainly nothing in their general relations as deposits elsewhere to render it improbable that both varieties of the volcanic flows might be interstratified at this place.

Damurka.

Near some small rocky hills south of Damurka, the soft white and ferruginous obliquely laminated sandstones of the superior jurassic groups, dipping slightly to the south, are interstratified with grey and whitish grey shales in which impressions of *Alethopteris* occur, being found, as usual, in one or two thin layers only. At the highest parts of the hills highly silicious liver-coloured quartzite-like rock, such as that mentioned near Kukrooa, forms caps, and some of the beds appear to be sharply contorted, and present alternations of white and purple claystone, but are much concealed by their own débris.

Gunna Peer.

In ferruginous clays and coarse sandstones near the temple of Gunna Peer are decomposing bands of bright red hæmatite; and purple, reddish, and white shales underlie a thick band of soft, white, sandstone with red layers, in which a *Gosain's* cave has been excavated just beneath the temple.

The remainder of the open country in this neighborhood is formed of the upper jurassic rocks, with a few isolated patches of the red volcanic rocks. Further to the northward it becomes low, alluvial, or of the barren Runn-like variety called Laana, and passes so gradually into the Bunnee and Runn that nothing like a line of demarkation exists. One slight depression of the surface north of Damurka is a constantly wet jheel.

Open country to north.

'Higher Tertiary'?—South and south-west of the range extends a broad plain at a slightly higher level than the alluvium that borders it on the south. In this plain some beds of cemented rock are occasionally seen cropping out here and there and in the sloping sides of water-courses, resting horizontally upon argillaceous and earthy reddish-brown deposits. These are probably referable to some of the higher members of the tertiary group.

Plain south of the hills.

The cemented rock presents different appearances in different places; it generally assumes the form of a conglomerate with a kind of pisolitic structure, made up of little nodules of kunkur. Some of these beds are worked between Pussoora and Chiree for building materials, a thickness of 10 to 14 feet being exposed, and among them are some bands of fine micaceous silty clay.

The pisolitic bed becomes more of a conglomerate or concrete in another place where *Balani* were found attached to and imbedded in the rock. A tough dark clay occurs below the *Balanus* conglomerate.

In a conglomeritic concrete, 4 or 5 feet thick, associated with fine grained obliquely laminated sandstone, occurring at the stream bank north of Pussoora, many small fragments of bone were found, also teeth and dermal plates, probably reptilian.

Stream near Pussoora.

North of Tappur.

In a bend of the same stream north of Tappur, a vertical section of 40 feet shows—

(Natural order).

3. Strong concrete and conglomerate beds.
2. Thick earthy clay, light-colored, kunkury.
1. Brown sandstone finely micaceous and very false bedded, dipping at low angles southward. No fossils were detected.

Clays near Pussoora and Chapoora.

Some plastic or friable saline clays and variegated shales lower in the series than those mentioned above occur in close proximity to the laterite north of Pussoora and again at the village of Chapoora, where they are sparingly gypseous. A few borings made by some *Pholadidæ* were observed in the clay.—F. F.

Eastward of Joorun.

To the eastward of Joorun the hills are somewhat broken, forming a double chain converging to the east, the southern ridge being the most lofty. Some of the rocks at the base of the northern side of the chain along the margin of the Runn so much resemble the upper jurassic rocks that they have been coloured as such upon the map.

The following section from the hills northwards will show the structure of this part of the country:—

	Natural order.		Ft.	In.
UPPER JURASSIC BEDS.	19.—Out in the low ground along the Runn soft, coarse, white sandstones, probably contorted, bedding obscure, high dips to the north were visible			
	18.—Purple and white beds with the ferruginous concretionary bands mentioned at page 105		30	0
	17.—Ferruginous bands	Dip north, nearly vertical.		
	16.—White sandstone			
	15.—Soft irregular sandstone ...		123	0
PASSAGE BEDS ...	14.—Ferruginous beds			
	13.—Purple sandstone			
	12.—Ferruginous bed			
	11.—Blackish ferruginous sandstone and white earthy bands	vertical.		
	10.—Blackish ferruginous sandstone ...	Dip N. 75° ...		
	9.—Yellow sandstone banded with red			
	(Hills commence here).			
PASSAGE BEDS ...	8. Purple and variegated sandstone.	Dip N. 75°	121	0
	7. Ferruginous bed.			
	6. Platy whitish sandstone and hæmatitic and conglomeritic beds, annelid tracks and plant fragments, a few obscure shell casts.			
LOWER JURASSIC.	5. Purple ferruginous beds with a thin band of quartzose conglomerate.	Dip N. 25°-70°.	481	0
	4. Yellow weathered shale.			
	3. Flaggy beds, white clayey and blue shales forming a thin band.		15	0
	2.* Coarse purple sandstones.			
	1. Red boley bed containing a few *Ammonites* and yellow and gypseous shales containing *Belemnites* and wood fragments.			

* (Beds here commence turning over to the south, and from being only partially exposed, their thickness was not determinable).

Throughout this eastern portion of the range rocks similar to those of the above section frequently recur, those of the hills being generally shaly and flaggy, with obscure plant impressions and some thick bands of sandstone in their upper part, while below associated with the shales are thin bands having a texture and colour not unlike a bluish gray quartzite. Ferruginous beds are very common among what have been indicated as passage beds in the above section, while the uppermost seen are coarse, rough, and fine white sandstones.

Some red and chalky white variegated and gypseous shales being the last rocks seen towards the Runn in the above section probably represent the sub-nummulitic group.

Joorun.

In the neighborhood of Joorun the deep glens which intersect the range afford good opportunities for observing its structure. A commanding summit called Roha hill rises to a height of 532 feet above the Runn (aneroid) in the centre of the range, but to the south of its anticlinal axis, the beds forming the hill having a steady dip to the south. The range still preserves its double character, other hills aligning themselves with this on the east and west, and a minor chain flanking them to the north passing close to the town of Joorun. South of all a small but bold group of rugged, serrated, conical, and flat-topped elevations rises abruptly from the sandy plains.

West of Roha hill.

The glens east and west of Roha hill expose black and dark-gray shales sometimes variegated with red, occupying the centre of the chain and doubtless, from their softness as compared to the neighboring rocks, having tended to produce under erosion the depression along the middle of the range.

Northern flanks of hills.

The rocks on the northern flanks of the hills near Joorun are frequently contorted or vertical, undulating along their strike. They consist of raggy beds, intercalated with which are thin flags and coarse friable whitish sandstones,

the group having a thickness of more than 100 feet. From beneath these rise the conglomeritic or coarse light coloured and purple or brownish sandstones, very obliquely laminated and containing highly silicious beds, which, either sharply contorted or dipping at high angles to the north, form the low outer ridge on the north side of the range.

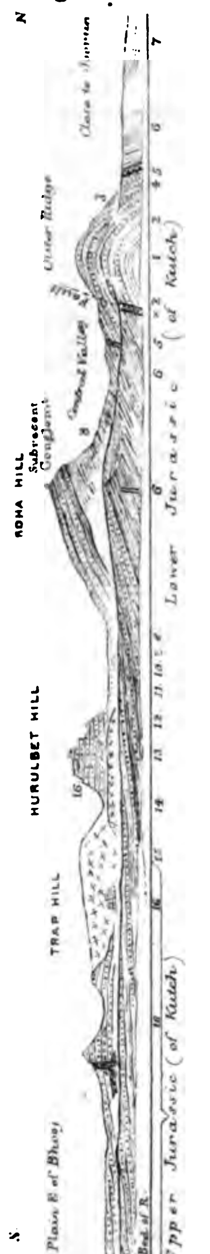


Fig. 8.—Sketch section to illustrate the arrangement of the rocks near Joorun.

Oblique lamination and contortion, &c.

The oblique lamination in some of these coarse beds is at times so excessive as to assume an appearance of unconformity, which is, however, only local, and the beds sometimes contain small bright red jasper-like fragments. It is hardly safe to trust to appearances of thickness among these contorted rocks, but in one place they were seen with a dip of 50° to 80° to the north, showing a steady thickness of 250 feet, which can be but a small part of that required to account for the portion of the series forming the north side of the anticlinal here.

Anticlinal axis.

In the gorge close to Joorun where the river crosses the outer ridge the axis of the anticlinal is found, its position so far to the

north being probably the result of dislocation accompanying a fracture occupied by a large trap dyke a few yards to the south. Crossing this dyke, a mass of shales and clays, varying from yellow to gray and black, and having a thickness of at least 300 feet, is met with. The only fossils they contain are a few small pecten-like finely striated bivalve shells so imperfectly preserved that they could not be determined.

Sandstone veins.

These beds are intersected by one or two curious narrow dyke-like veins of blue pyritous sandstone or quartzite which distinctly cut through the beds for several feet without dislocating them, though only an inch or two in thickness. Resting on these shales are the sandstones which form the summit and south side of Roha hill, and then a long succession of clayey, flaggy, and shaly beds overlaid by the red variegated yellow, purple, white, and ferruginous sandstones of the upper jurassic group. The section being as follows from near Joorun southwards up the river course :—

Dip N. 45° to vertical.	
7.—Fine grained flaggy light coloured beds	380 ft.
6.—Coarse, weathered, friable white sandstone and shales, dip to N. 80°, or vertical	
Trap dyke, dark gray, slightly amygdaloidal, finely crystalline ...	
5.—Muddy gypseous brown sandy clay	
4.—Rugged sandstone and soft raggy clay	
3.—Sandstone and conglomeritic beds with silicious layers and red jaspery fragments	250 „
2.—Soft buff sandstone overlying purple obliquely laminated ditto...	
1.—Very hard fine brownish purple thin-bedded sandstone and purple quartzose conglomerate over soft rugged orange earthy beds, with fossil wood	150 „
———*Axis.*———	
Dip S. average 35° or 30°.	
5 or 6.—Soft sandy clays containing numerous *Belemnites* like *B. hastatus*	300 „
Dip S. 30°.	
Fault and trap dyke here strike north of east slightly : trap gray and solid	
Red, greenish, black and gray shales, with few fossils ...	
6.—Sandy and shaly beds with traces of *Ammonites* and plants seen west of section, thickness uncertain	? 100 „

? 7.—Yellow sandstone with annelid tracks, purple and yellow sandstones with raggy clay partings and containing close grained fragments of fossil timber, beds ripple-marked in places ... (In a nullah from Roha hill, which enters the main stream here, occurs about 50 feet of horizontal sub-recent calcareous sandy concrete). 8.—Soft white sandstone with ferruginous nodules and large quartzose masses, being with the last mentioned beds the representatives of the sandstones capping Roha hill	200 ft.
9.—Thin-bedded pale yellowish variegated shale, white and purple, thin purple sandy bands	150 „
10.—Soft, thick banded, blood-red, yellow and white obliquely laminated sandstone with soft red ferruginous bands ... 11.—Ferruginous rugged band	100 „
12.—White sandstone	20 „
13.—Rapid alternations of platy, red, ripple-marked, and soft white sandstone with two narrow purple zones	100 „
14.—Purple sandstones occasionally micaceous ... ... 15.—Ferruginous beds very rugged and red alternating upwards with light coloured flaggy and shaly beds, dip to south becomes as low as 5° to 10°	150 „
16.—White rugged sandstone, some red, sandy, and shaly bands and occasional beds of conglomerate in the upper part ...	200, &c.

Hurrulbet hill, &c.

Near the place where this section terminates is the semicircular group of rugged serrated conical and flat topped hills before mentioned, one of the most conspicuous of which called Hurrulbet hill is formed of a mass of white and purple horizontally undulating soft and hard irregular blotchy sandstone. A trap dyke, from 9 to 15 yards wide, passes its foot on the east side with a south-westerly strike, and all the other hills in the neighborhood belonging to this group have intrusions of the same dark gray or basaltic trap passing through them and forming their summits. On the most westerly hill the trap forms a heavy capping of considerable thickness, and although not distinctly stratified may be an extension of that which overlies the beds of the Buchao and Lettera range.

The remainder of the ground in the vicinity of these hills is occupied by coarse, white, and black ferruginous sandstones, with red and purplish quartzose bands, the whole having the ordinary superior jurassic aspect.

From Roha hill westwards extends one of the most striking features of the whole chain called the Kâss, a steady strong escarpment of light colored sandstones overlaid by raggy shales dipping to the south at 15° and resting upon the dark central shales of the range. Its scarped northern side has an elevation of about 250 feet and coincides in general direction with a continuation of the large dyke found to the south of Joorun, which, flanked by some others, has been traced to its foot, thence obliquely ascending to the very edge of the scarp. This no doubt owes its origin to the fractures occupied by these dykes combined with the superposition of the sandstones upon the much softer shales.

The Kâss.

The beds are but slightly, if at all, fossiliferous where examined, and their thickness, including some which are concealed at its northern foot, must be quite 500 feet. Here and there patches of sub-recent conglomerate or concrete occur high up on the precipitous face of the scarp, their stratification dipping south by east at 35°, 40°, and abutting against the steep slope of the ground.

Crushing and fracture of layers.

The stream valley west of Roha hill exposes the anticlinal axis beneath the northern flanking ridge. The force with which the rocks were contorted has produced complicated convolutions of the shaly laminæ between some of the harder beds, as at *a*, Fig. 9, while in places the strata appear to have yielded to both crushing and stretching forces disrupting the continuity of flaggy layers in shaly beds lying between strong conglomeritic sandstones, as at *b*, Fig. 9.

a. *b*.

Fig. 9.—Crushing in shales, near Roha hill.

At a short distance south of this the stream crosses the large dyke before mentioned, as coinciding with the line of the Kâss scarp. The fault which accompanies it is well seen, its north wall being formed of gray shales, while it is in

Large dyke.

Fig. 10.—Fault and Trap Dyke on the Nariery Nuddi, sub-recent conglomerate in mid-distance and Roha hill beyond.

contact with strong sandstones on the south. Its width is here 93 feet, and the alteration which it has produced in the neighboring rocks strongly marked. This has extended into the shales for about 42 feet, these showing a 28-foot band of deep black color crossing the beds parallel to and at a distance of 14 feet from the dyke, the intervening space having been from intensity of heat altered to a lighter colour. The sandstones are also changed, being very hard for 20 feet from the dyke, and within this distance the *Belemnites* which they contain, instead of being composed, as usual, of dark coloured carbonate of lime (arragonite), have become altered into a white opaque porcellaneous substance. Shales succeed in such a position as to overlie these sandstones, and are intersected by some of the same peculiar pyritous silicious sandstone veins as occur in the glen to the east. The whole of these beds pass steadily underneath the shales and sandstones of Roha hill.

A mass of sub-recent concrete, such as occurs in many of the glens of this range, forms the upper part of the river banks (in the middle of the sketch, Fig. 10), extending

Sub-recent concrete.

for some distance on each side. Where this allows the large trap-dyke to be traced, it is frequently seen in junction with the shales altered to black and red for several feet from the dyke. Between this dyke and a neighboring one to the north, not far from Wandra, loose fragments of *Ammonites* were found scattered about.

Outer range.

Westward of this, the light coloured, brown and purple sandstones of the outer range are much contorted, disappearing with very high northerly dips in the low ground along the Runn. To the south-west of Lodaee they are intersected by a very intricate and tangled trap intrusion, forming a hill somewhat higher than the adjacent portion of this minor range, which becomes broken and gradually dies out from Lodaee to Kota. Another similar intrusion occurs to the south. The Kâss scarp on the other side of the chain rapidly loses its elevation south of Lodaee, but the feature is continued in a low scarp of the same character conterminous with the remainder of the chain near Rodur.

Most lofty part of chain.

Embraced between these two low external ridges rises the most lofty portion of the chain reaching, as stated, at Hullaman above Hubbye, the elevation of 800 feet above the Runn, and having summit heights not greatly less both to the east and west.

The axis of the anticlinal is here more central, declining, however, in the above directions, so that the beds fold round or "nose" at either end, giving to this portion of the chain an elongated oval form, the longest slopes as elsewhere along this line of disturbance being those to the south.

The rocks are chiefly light coloured sandstones and gray shales, weathering of a rusty colour, the latter predominating towards the base. Some solid, dark-gray impure limestone occurs, and many of the beds are highly fossiliferous, containing the marine forms characteristic of the lower jurassic group of Kutch.

Section.

To obtain a definite idea of the succession of these lower beds, advantage was taken of the steady northerly dip on that side of the anticlinal near Lodaee to make a detailed examination of the rocks down to the centre of the axis or as near to it as possible. The section subjoined was carried southwards from near Lodace over a distance of about a mile and three quarters. The exposures of the rocks, although frequent, were not sufficiently continuous to enable more detailed measurements of each set of beds to be made, portions being concealed here and there, and in the hills the thickness had to be estimated with such accuracy as circumstances permitted.

(Natural order).

North.

ALLUVIUM.

Coarse white sandstone ... ... Dip N. at 8°.

(May belong to the transition or upper jurassics of Kutch).

Horizontal space blank, about 150 feet.

Dark ferruginous band. Strike E. 10° S. vertical	300 ft.
Thin, hard, yellowish beds, often alternating with shales, some conglomeritic beds of coarse sandstone, also strong bands of coarse rugged sandstone, dip north, high or vertical. They contain small corals, *Terebratula*, oysters, *Belemnites*, and layers of shell fragments ...	1,500 ? „

32.—Light coloured sandstones, undulating, general dip E. at 20°.

31.—Small escarpment of sandstone, dip low to W.

Note.—The beds here described may be parts of sharp curves denuded above, otherwise they would have the doubtful thickness assigned. They are seen at a little distance from the line of section.

30.—Shales weathering yellow, dip N. at 30°. ...	Dip N. at 30°	700 „
29.—Sandstones		
28.—Shales similar to above		
27.—Sandstones		
26.—Shales with red bands		
25.—Raggy beds		
24.—Shales similar to above without the red bands ...		

23.—Strong sandstone, dip N. 10° E. 45°.

22.—Clayey shale.

21.—Sandstone.

20.—Shales with ferruginous and oolitic thin lumpy layers, contain large *Ammonites*, (*Stephanoceras*, n. sp.), and *Astarte* ... ... (In harder bands in these clayey shales are *Ammonites* and wood). Yellow shelly calcareous finely oolitic beds with *Trigonia*, *Belemnites*, small Oysters, *Terebratula*, large Oysters, indefinite fragments of plants and wood in sandy layers. 19.—Thin red bands full of shells, among which are some small univalves and some *Terebratulæ*... ...	Dip N. at 45°	60 ft.
18.—Fine, greenish, olive, fossiliferous sandstone with casts of *Ammonites* in carb.-lime, *Belemnites*, *Terebratula*, large and small Oysters (*O. Marshii?*),—some of the *Ammonites macrocephalus* over 15 inches in diameter, pieces of bone and fossil wood ...	Dip N. N. E. at 30°	540 „
17.—Reddish and yellow shelly beds	Dip N. at 30°	
16.—Greenish olive, sandy calcareous beds with *Trigonia*		
[Gap for about 100 yards.]		
15.—Thin platy sandstones with large ripple mark ...	Dip N. at 30°	60 „
14.—Coarse sandy beds, some fossils		
13. Hard brown band		
12.—Lumpy nodular calcareous bed, full of corals ...	Dip N.	
11.—Sandstone, generally light coloured, some reddish, some more flaggy, softer portions, and a band thickly covered with casts of small *Nucula*... ...	Dip N. at 25°	200 „
10.—Very hard brownish layers over massive white sandstone ... ... 9.—Soft yellowish sandstones, portions hard and shelly, gray and weathered yellowish, contain small gastropods ... ... 8.—Pisolitic layer, with calcareous sandy matrix at top of a shaly band with gypseous and ferruginous red layers, contain *Ammonites* and *Nucula*... ... 7.—Shelly layer with large *Astarte* resembling *unilateralis* 6.—Shaly bed with *Ostrea*, *Trigonia*, &c. ... ... 5.—Dark olive layer ... ... 4.—Layers full of shell fragments ... ... 3.—Strong whitish sandstone ... ... 2.—Greenish white flaggy bed speckled red and coarsely rippled in two directions one over the other at right angles ... ... 1.—Greenish and red flaggy beds with crowded casts of a small, apparently new, species of *Nucula* ...	Dip N. at 25° and 30°.	1,400 „
South.—(Other sandstones and shales below)	From Nos. 1 to 30	2,960 ft.

For the first 3,800 feet of horizontal distance from No. 30 northwards, the rocks, there on edge, are not well exposed, though frequently seen to the east of the section line. As they are either vertical or contorted, the evidence of thickness which they afford carries with it some amount of doubt. Although the thickness given, however, may be excessive, the rocks must still have a very considerable bulk, and they certainly are not repeated in the section above detailed; from which the lower group of the jurassics of Kutch would appear to have a depth much exceeding 3,000 feet. The aspect of the beds occasionally recalls that of the Béla group, but the shales and sandstones from Nos. 24 to 30 are unknown along the Putchum, Kurreer, and Béla range, and the fossils, although to some extent similar, have, as an assemblage, a different aspect, *Ammonites* here being much more frequent, containing some of the largest varieties found in Kutch, and including *Ammonites (Phylloceras), Lodaiense,* Waagen, MSS., *A. (Peltoceras) perarmatum,* Sow., *semirugosum,* Waagen, MSS., *bidens,* Waagen, MSS., *A. (Stephanoceras) macrocephalum ? Perisphinctes,* of various species.*

Besides these also occur two species of *Pleurotomaria* of the type of *P. Agathis, Astarte compressa, Unicardium,* sp., *Nucula cuneiformis, Ctenostreon pectiniforme, Ostrea Marshii, Pholadomya inornata* of Sowerby, &c.

The eastward inclination of the anticlinal axis indicates the occurrence of lower beds to the west; these crop out of the sides of the ravines from the Hullaman summit, but consisting largely of perishable shales weathering away, they have overrun the slopes, leaving protuberances on the hill sides, marking the places where harder beds at wide intervals are concealed beneath. Where seen, these lower shales have a raggy look, weathering of an ochreous colour with thin sandstone and calcareous layers, some of the latter being crystalline and full of broken shell fragments. Their thickness in excess of the above section is roughly estimated at 300 feet.

* These MSS. names refer to a detailed Monograph on the Ammonites of the Kutch beds, by Dr. W. Waagen, now in the press.—T. O.

Kota glen.

In the glen south-by-west of the village of Kota, lower beds, but not quite so low as the last, occur; they are chiefly shaly with thin calcareous shelly bands. Within this glen, which is formed by the meeting of three or four mountain ravines, are some picturesque ruins (called, after a former celebrity of Kutch history, Lakafullane-ka gud, *i. e.*, fort) surrounded by the remains of a wall which encircled the whole glen. Not far from these ruins, the stream courses from the west and south expose a mass of dark trappean muddy shales and dark masses much resembling contemporaneous flows with black shaly partings; among these are some hard, black, shelly bands, and in a concretionary rubbly bed between two greenish trappean shales or ash beds, some *Belemnites*, &c., were observed, not, however, in good preservation: a few other fossils occur higher in the series. The occurrence of these apparently contemporaneous traps is so complicated by the existence of intrusive dykes of the ordinary doleritic or basaltic character that little certainty could be felt as to most of them not being merely injected between the beds. The associated black pencilly shales also closely resemble those of the stream section south of Joorun, or the altered rock on the north side of the great dyke figured at page 150 (stream west of Joorun, called the Bothor or Narriery nuddi by different natives). The upper portions of the glen and neighbouring hills are formed of light coloured pink, purple, and variegated sandstones nearly horizontal or sloping slightly to the west over the axis of the anticlinal and dipping to the north at 30° on that side of the range, but passing on the south more gently downwards with the slope of the hills.

Traps resembling contemporaneous deposits.

Subrecent concrete.

High up in some of the ravines of Kota glen at elevations of some 300 feet above the Runn are drift-like patches of subrecent concrete which evidently once occupied larger spaces in the hollows, but are now in course of removal.

This concrete, sometimes a coarse conglomerate, formed of large blocks of the local rock with a calcareous matrix, occurs also at the foot of the chain in the low ground between Kota and Koonrea. It varies here in colour from gray to rusty yellow and black, and in some places appears to give an unusually flat surface to the ground.

Upper beds of this country.

The beds which flank the chain along here on its northern side are strong, coarse, yellow sandstones and flags, generally dipping at high angles to the north, but sometimes bent into curves, the axes of which slope to the west.

Further out in the narrow plain or 'Kanta,' which skirts the hills, are greenish shales and pale purple sandstones containing *Ammonites*, *Belemnites*, Oysters, and other bivalves, while above them are black sandstones and red shales. The beds on the northern side of the chain must have a large thickness, a northerly dip of 30° has been seen along a line crossing them for more than half a mile, which did not traverse all the rocks of the section, so that it will not be too much to estimate them at over 1,000 feet.

Koonrea.

South of Koonrea, the anticlinal becomes low and open, the rocks undulating over the country in wide sweeping curves, with gentle inclination to the westward; some massive beds of coarse, orange, white, and red sandstone with ferruginous layers forming abrupt hills of as much as 80 feet. In this country also, bands of soft gray and rusty shale, often 20 feet thick, occur, while in the river Kara at Rodur and to the north, they form vertical cliffs from 60 to 80 feet in height, undulating over the country with low dips in different directions. Among them are strong beds of soft sandstone light in colour and of coarse texture, with some bluish, gray, highly silicious compact layers.

These beds bend round the western end of the anticlinal, so as to overlie the purplish sandstones which cap Wadha hill, and form its

southern and western slopes. In the bed of a stream which enters the larger one near Rodur temple, and somewhat more than a mile and a half from this junction, is a fossil locality furnishing the nearest marine remains, in the ascending section, to the plant and coal-bearing beds of Trombow to the south. The succession observed here is—

Rodur fossil beds.

Dip S. S. W. 10°.

6.—Thick, red, and yellow variegated sandstone	22 ft.
5.—Banded and variegated gypseous shales	
4.—Gray shales with dark-blue calcareous bands and ferruginous nodules, the latter sometimes containing very perfect casts of *Ammonites* of unknown species	
3.—Gray calcareous bed with numerous *Belemnites*, traces of *Ammonites*, *Ostrea Marshii*, *Gervillia*, *Astarte compressa*, *Rhynchonella*, *Terebratula*, *Trigonia* : thickness 2 ft.	
2.—Purplish red bed full of angular *Serpulæ* : 18 inches ...	
1.—A calcareous bed full of *Terebratulæ* overlying strong sandstones	

The section occurs in the valley between the southern outer ridge and the main body of the hills.

The sandstone No. 6 is succeeded above by others of finer texture, thinner, and of gray colour, associated with ferruginous layers and some shaly beds, all dipping to the south-south-west at 15° and 20,° the angles, however, decreasing in that direction as the plain to the south is reached. Near the crest of the small outer ridge are some dykes of gray trap and a soft greenish variety, which may be either contemporaneous or intruded between the beds.

SECTION 6.—PORTION OF THE CENTRAL PLAIN NEAR BHOOJ AND TO THE EAST AND WEST OF THAT PLACE.

Position.

The extensive plain which separates the Charwar and Katrol range from the broken chain near the Runn, a portion of which has just been dealt with, is everywhere underlaid by the upper jurassic rocks. It is crossed by the courses of several streams which rise among the southern hills and find their way through breaks in the northern range out to the Runn. A few from the eastern side of the plain, however, flow in that direction down to the mangrove swamps at the head of the Gulf of Kutch. The surface of the ground undulates, and is broken here and there by groups of rugged hills or isolated peaks and low lines of escarpment formed by the outcrops of beds, affording more resistance than usual to the erosive agencies which continue to reduce the soft strata of the plain to sand.

Sand.

Over much of the latter this lies so thickly that a circuitous journey is preferable to crossing such heavy tracts where the winds arrange it into miniature knolls and domes resembling those of a sea coast.

Quartz reefs.

Most of the hills are of the coarse white sandstones, but some are formed by intrusions of trap, and low long ridges or reefs of quartz are very common, in some places clustered together or intersecting, but having no persistent similarity of direction. These quartz reefs are prominently noticed in, and some illustrations given with, Colonel Grant's paper already mentioned, where they are described as '*Walls on the Runn,*' *&c.* They have not been observed, however, on the Runn itself, only on its edge, and much more frequently scattered over the plain now under notice.

Their resemblance to walls is only attributable to regularity of jointing, which is not, however, nearly so general as to become characteristic, and they vary in height, width, and length, being generally considerably above the level of the plain, 30 feet or more wide, and often traceable for more than a mile. Their junction with the adjacent sandstones is sometimes sharply defined, but frequently indefinite, and in some places, particularly on the southern slopes of the Katrol range, these reefs occur along the courses of trap dykes.

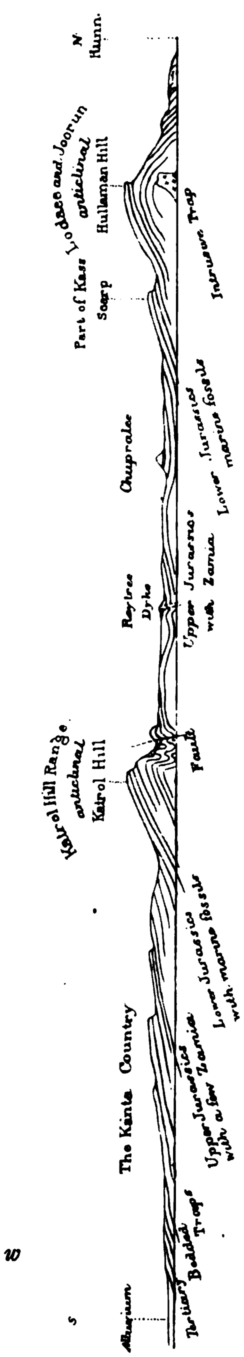


Fig. 11.—Sketch section to illustrate the structure of the eastern part of Central Kutch.

Their composition varies from opaque white or clear quartz to a dark blackish brown compact variety of quartz rock. Several have been marked upon the map, and figures of two are given further on. The position of the plain and structure of the country will be understood by reference to the annexed sketch section. (Fig. 11).

Kunyabuy.

At the eastern side of the plain and in the neighbourhood of Kunyabuy, coarse white sandstones and ferruginous beds are occasionally seen, but much

of the country is occupied by superficial ferruginous deposits which may have been formed from the waste of lateritic beds *in situ* further east. Just to the west of the above named village, a little pale sandstone of coarse texture and greenish tone projects from the plain, its relations being obscure, but it probably belongs to the ill-defined sub-trappean grit group.

Pudder.

Further west, the coarse, upper jurassic, white and ferruginous beds are seen, and in the neighbourhood of Pudder, small nullahs show coarse gravelly and earthy alluvial 'rain wash.' White sandstone and highly ferruginous, silicious and conglomeritic sandstones, much disturbed, are crossed by a long dyke of dull blackish and weathered trap at Reytree to the south-south-east; the trap, including masses of sandstone, considerably altered. Thence to the foot of the Katrol hills, ferruginous and white sandstones with a general southerly dip are occasionally seen in the nullahs.

Kokma.

In the neighbourhood of Kokma and Bhoojooree, the white quartzose gravelly sandstones and ferruginous beds are violently contorted, sometimes completely vertical, striking east 20° north, but nearer to the Katrol fault dipping to the south by east.

In a stream south-south-east of Bhoojooree are some fine white shaly and sandy beds containing numerous specimens of *Palæozamia*, *Lycopodites cutchensis*, Morris, *Cunninghamites* (?), and other plants.

Here a long section in the rocks is exposed, but their succession is confused by oblique slips and cross-bedding. Further south, near the village of Lair, the white upper beds are obscurely associated with some of the sub-trappean grits. These occur again about a mile distant to the north-north-east, dipping at 30° to the south and south-south-west. They are laminated here, and seem to have derived the trappean materials either from partial disintegration of trap rocks or from contemporaneous deposition in the form of ash.

The hills near Kokma are formed of the usual upper jurassic rocks, showing an obscure dip to the eastward. The trappean grits harder than usual, and accompanying altered silicious sandstone, overlie those to the west; while two small outliers of the stratified traps occur to the north, apparently underlying some red and dark purple volcanic-looking tufa and lateritic beds.

North from Pudder.

Northwards from Pudder a low range of rugged sandstone hills rise from the plain at Chuprole, extending in a south-westerly direction by Kaleat-bowrie (abbreviated to Karetry). Beyond this it is broken and crossed by the valley of a tributary to the meeta (sweet) nuddi, but continues for some distance, forming the ridge called Vatone Hill near Lakhan, which terminates to the west in an intrusion of grey trap.

Chandrua hill.

Just near the village of Lakhan, some of the sub-trappean grits re-appear, the river there crossing a pocket in the coarse upper jurassic beds, occupied by these curious semi-trappean rocks, their bedding, where visible, being quite discordant from that of the underlying sandstones. North of this, the bold sub-conical hill of Chandrua rises to a height of 270 feet above the plain (and probably 700 above the Runn, aneroid measurement). The sides of this hill are very steep to the north and west, and expose coarse, soft, white, red and pink sandstone varying to what might, for want of a better distinguishing name, be called quartz gravel stone, with hard ferruginous sub-granular bands so silicious as to resemble a brown quartzite. The sandstones have indefinite white tubular casts like annelid burrows or fucoids, and are so obliquely laminated, and so amorphously weathered, that their true stratification is all but obliterated, in some places, however, appearing to dip to the east by north at 30°, 45°, and 50°. The white rocks are most prominent below; brown and ferruginous beds forming the uppermost part of the hill.

Some of the silicious granular varieties of the stone forming the west side of the hill used formerly to be worked for Native *chuckis*, or mill-stones.

TROMBOW COAL LOCALITY.

This place having attracted some attention on account of the discovery of a bed of coal, the substance of field-notes on the locality is given separately.

The *meeta* river, or branch of it which passes by Trombow, there, and between that place and Chandrua hill, passes through a deep channel in white, yellow, variegated and ferruginous, coarse, obliquely laminated, thick and thin bedded sandstone with some bands of grey shale, the whole having undulating dips to the southward and south by east, averaging about 5°. The same varieties of the upper jurassic beds prevail to the south as far as the Katrol Hills, the surface of the ground gently ascending, so that notwithstanding numerous open undulations, the vertical thickness of the rocks must be considerable, and, when the hills are included, probably amounts to several hundred feet. From Trombow northwards the same general southerly dip has been traced for about three miles to the marine fossiliferous locality behind the outer ridge of the western portion of the Lodaee and Joorun range, the rocks differing only in being more generally thin-bedded with a greater preponderance of purple, reddish, and rusty ferruginous bands such as are usually found intermediate between the upper and lower parts of this series. For this long distance no fossils could be found, and the indefinite line between the two groups has been assumed to pass near the southern foot of the above-mentioned ridge.

The rocks.

The succession, however, cannot be said to be unbroken, three parallel faults crossing the river from east to west at short distances northward of Trombow village. As these faults all 'hade' to the south at high angles, the presumption is,

Faults.

that their united effect has been a downthrow in that direction, the amount of which is undeterminable, as the beds brought into irregular contact have no peculiarities whereby they might be recognised in other parts of the section. The two nearest of these faults to Trombow are but a few yards apart, and show themselves in the cliff on the right bank of the river at a spot where it turns westward for a short distance, forming a deep '*drao*' or pool. The red beds included between these two faults contrast strongly with the white ones on either side, and a mass of crushed white rock which occupies the northern fracture. As the white sandstones both to the north and south of the faulted ground rest upon some thin red flaggy beds (having, however, on the north side some intervening shaly layers), it is perhaps possible that the throw of one fault compensates for that of the other, leaving the *country* on each side nearly in its natural position and not more affected by displacement than it would have been had the intervening red sandstone ground been occupied by a large trap dyke in a simple fissure.

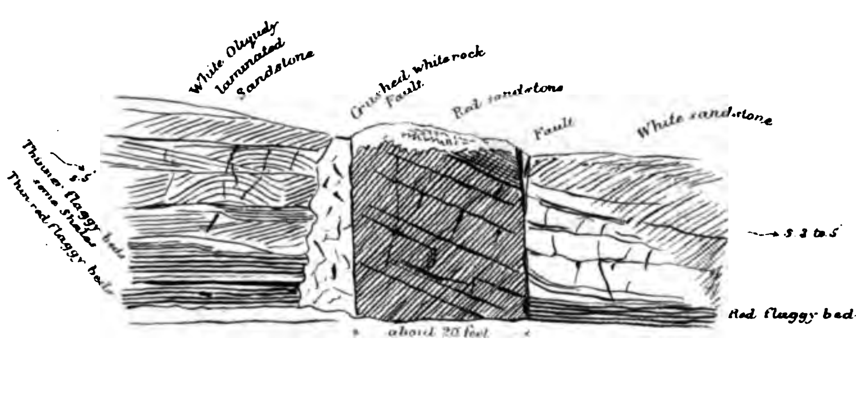


Fig. 12.—Diagram of faults crossing river at Trombow.

The other fault which occurs within a quarter of a mile to the northward, further down the stream and upon its opposite bank, is most clearly

seen. The river bank is here about 20 feet in height, showing the following section on the north side of the fault:—

Dip S. 3° to 5°.

		ft.	in.
UPPER JURASSIC...	6.—Red sandstone	13	0
	5.—Grey shale	2	3
	4.—Carbonaceous shale with a bright, brittle, coaly layer of 2 inches	0	5
	3.—Layer of sandy shale	0	5
	2.—Grey shale	2	0
	1.—Red sandstone layers	3	0
	(Red sandstone). TOTAL ...	21	1

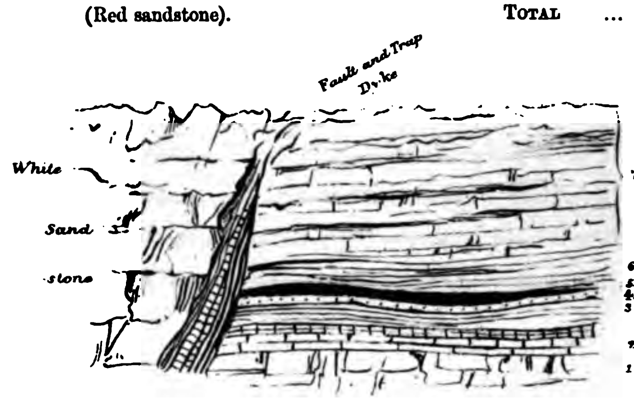


Fig. 13.—Diagram of fault and thin layer of coal, on left bank of river near Trombow.

To the south is massive white sandstone, and the fault itself is occupied by purple amygdaloidal trap or lava, and crushed black calcined looking shale, amongst which some cindery fragments may represent portions of the adjacent carbonaceous bed. The throw of the fault appears to be to the south, but the amount is not determinable.

Coal.

The little seam of coal in the carbonaceous shale here varies in width up to two inches, and seems to die out within a few feet on each side; it is bright and brittle, the largest fragments obtainable soon breaking down into minute pieces; a rough attempt to ignite it upon the spot was but partially successful. The associated shale is full of small plant remains of the usual striated

character, and in some flaggy layers of the overlying sandstone near the top of the cliff, a few fronds of *Palæozamia* were obtained. Others occur in a bed of pale grey shale on this bank of the river at about eight feet from the base of the cliff and nearly opposite to the place where the double fault above mentioned is seen, the dip being still south at 3° to 5°.

In a similar shale bed at a short distance still further up the stream are *Palæozamiæ, Taxodites (?), Cuninghamites (?), Pecopteris,* and a moss-like plant, the *Taxodites,* having the carbonised black fronds strongly relieved upon the bedding surfaces of the grey shale; portions of the leaflets possessing sufficient pliancy to separate from the shale while damp without breaking. (Plants in an almost identical state of preservation have been found in the Nerbudda valley in the Jabalpúr series).

Principal coal seam.

The principal coal seam of Trombow occurs on the right bank of the river directly opposite to the village, underneath a bed of red and yellow variegated sandstone fifteen feet thick, associated with some thin ferruginous layers beneath and a band of grey shale through which an adit has been opened, apparently in connexion with an old shaft at a little distance from the bank, and at the bottom of which water could be heard falling, while air, sensibly warmer than the surrounding atmosphere, was felt to issue from it. Below these shaly bands are white and purple sandstones with some layers of the peculiar ferruginous concretionary rock mentioned and figured at p. 115. Associated with these also are a couple of two-feet bands of spongy-looking rough sandstone with obscure annelid (?) tubes. Beneath these come the beds on the south side of the double fault before mentioned, all the rocks exhibiting abundance of oblique lamination.

Since this place was visited by Mr. Blanford, falls from the roof of the adit have so blocked it up that the coal seam could not be reached,

nor was it traceable in the cliff outside. To quote from his paper on the geology of Kutch, the seam is 1 foot 4 inches thick, overlying blue clay with carbonaceous markings, and immediately succeeded by a band of carbonaceous shale a foot thick, the section being thus:—

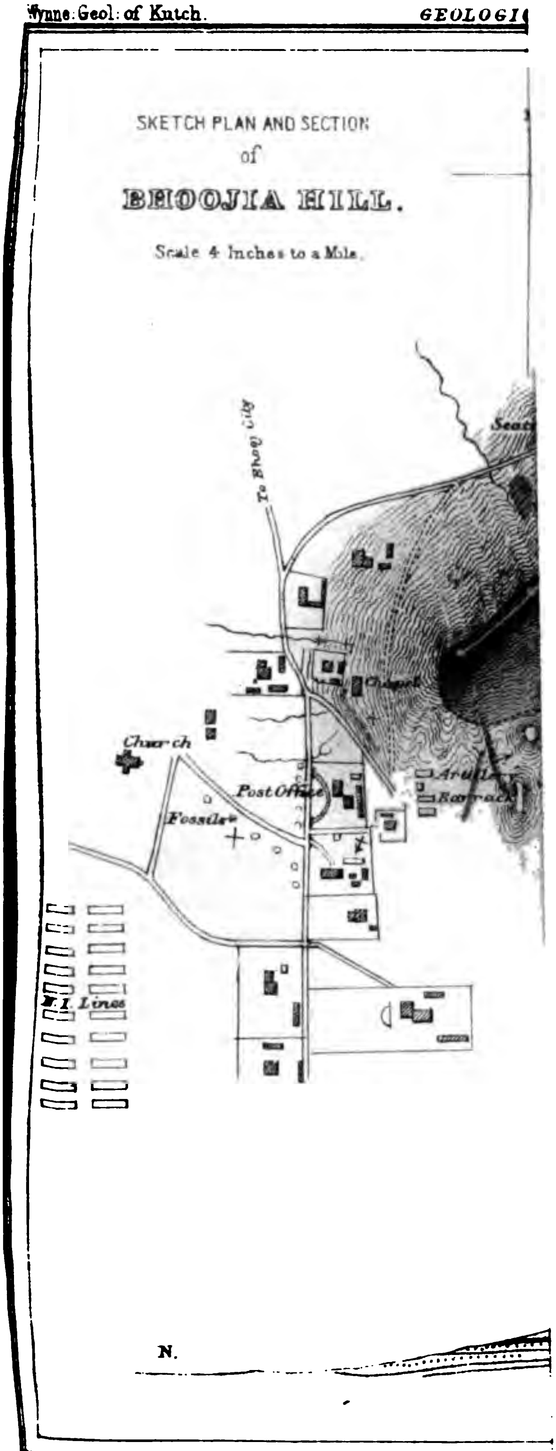
	ft.	in.
Coarse brownish and white sandstone, very falsely-bedded ...	12	0
Ferruginous sandstone	0	6
Coarse white false-bedded sandstone with carbonaceous streaks, especially abundant towards the base	2	0
Ferruginous parting	0	1
Coarse white and yellowish sandstone, false-bedded and containing carbonaceous streaks in places	4	0
Carbonaceous shale, passing down into	1	0
Coal	1	4
Blue clay with carbonaceous markings.		

"The middle 8 inches of the coal is very inferior, being rather a shale than coal; only about 8 inches is really good; this is bright and firm coal." It will be seen from this that the coal seam here is differently situated from that to the north, which is probably on a lower horizon. Besides the small trap or lava dyke already mentioned, there are two other intrusions of the ordinary solid grey trap in the vicinity forming small rugged hills at a short distance from the west bank of the river.

On that bank also subrecent concrete occurs of a sufficiently calcareous nature to be burned for lime.

Thickness of beds.

It is only easy to determine satisfactorily the thickness of the upper division of the jurassic rocks in the plain to the east of Bhooj owing to the lowness of their dip and the probability of the existence of numerous faults. Calculations from data so affected are liable to error, but making allowances they may have a depth of nearly 3,000 feet; while that of the beds belonging to the lower group to the north may exceed this by a considerable amount as already stated.



A B Wynne

Lithographed in Colors at the

NEIGHBOURHOOD OF BHOOJ.

In the vicinity of Bhooj station and city, the slope of the plain and run of the streams is still to the north, the most conspicuous feature of the country being the hill of Bhoojia close to the camp and east-south-east of the city. It is formed largely of trap, rises above the plain to a height of from 300 to 350 feet, as the inequalities of this are considered, and is crowned by the walls of a large fort enclosing a steep valley on its northern side. The camp is situated on the western and south-western declivities of the hill, commanding an extensive view of the Charwar and Katrol range, the hill of Wurrar, rising over a steep intervening escarpment beyond the city, the valley of the Kara river, and the distant peaks and summits of Vichia, Kundwinga, Drabwa, and Nunao to the west, appearing above long lines of rocky ground which bound the valley of the Kara in that direction.

Bhooj.

All round Bhooj the rocks are of the usual coarse, white, and purple, variegated, ferruginous and shaly character, marking the upper part of the jurassic series. They have low dips to the south and south by west, seldom exceeding 4° or 5.° One or two *Palæozamia* impressions were found lying loose on the western slope of Bhoojia hill, but the red flaggy layer which contained them could not be found *in situ;* some excavations, however, for the purpose of planting trees at a place midway between the Post Office and the Church passed through white sandstones and gray shales, in the latter of which a few definite impressions of similar plants were observed.

A band of marine fossiliferous rock, crossing apparently through the camp and passing close to Bhoojia hill, is indicated upon Mr. Blanford's small sketch map; but the closest search has failed to find anything of the sort, and it appears to have been introduced upon information referring to another place in the lower division of the jurassic beds to the southward.

The country about Bhooj is particularly full of those long lines of separation, which fault-like so frequently occur in the upper beds, and a broken fault crosses the ground from east to west just north of Bhooj city.

BHOOJIA HILL.

The structure of this hill, Plate III, is somewhat complicated. Its northern and western slopes are of the usual white and ferruginous sandstone, above which a sheet of dark basaltic trap with small crystals of olivine occurs. From its position this basalt might either be a bedded flow dipping to the south or an oblique dyke. It is highly magnetic at several parts of the hill, deflecting the magnetic needle to an extent which may explain the impossibility of making out the points given as fixed here by the Trigonometrical Survey. To the eastward from beneath the highest summits, the basalt is underlaid by, and intercalated with, a rapidly increasing mass of soft, ? ashy, sandy rock of greenish yellow colour, passing in places into a hard silicious trappoid sandstone of coarse texture, containing fragments of woody plants. From a well sunk inside the fort at one of the lowest points, a black variety of this rock has been taken, showing a difference in its vertical arrangement, and its rather indefinite bedding, where traceable, is seen to be nearly horizontal or to dip at low angles to the south, carrying it out over the low slopes of that side of the hill. Where some steep spurs and small peaks at the eastern and north-east sides of the fort occur, these are formed either of the jurassic sandstones, or of basalt and amygdaloidal trap. Lines of fissure, and sometimes of fault, traverse the western sides of the hill in more or less northerly directions, some containing ordinary gray and others purple lava trap, as shown upon the annexed plan; and just near the gateway of the fort, the jurassic and sub-trappean grits are complicated by contortions and slips. On the slopes of the hill, too, the intricacy of the relations are increased by the occurrence of patches of subrecent concrete.

From Bhoojia to the conical sandstone hill on which Soorul temple stands, and near the latter, the sub-trappean grits are occasionally seen, the trappean blotches and interstitial portions weathered out into little cavities on the surface of the rock, which sometimes occupies pockets or wide fissure-like spaces in the underlying jurassic beds. In the vicinity of this temple also some small intrusions of basaltic trap form little hills associated with white sandstones, which, apparently from contact, have assumed for some distance a perfectly columnar, pentagonal, or hexagonal structure.

Outcrops.

One or two strongly marked escarpments of the white and ferruginous upper jurassic rocks extend from the parade-ground westward, crossing the Mandavee road, their beds passing at low angles into the portion of the plain to the south. They are crossed by 'reefs' as usual, and on the hill over the Butts, these and oblique lamination unite to produce utter confusion of the stratification in one place, while alternations of thinner and more ferruginous beds beneath are strongly contrasted by reason of their regularity close beneath and along the scarp.

North-west of city.

North-west of the city a small basin surrounded by sandstone hills, on one of which is a conspicuous white temple, is occupied by ordinary gray and basaltic trap, some of the red variety with white amygdala, and a rubbly sub-trappean looking deposit largely composed of trap with numerous grains of white quartz and some enclosed masses of lumpy basalt.

North of Bhooj.

The lower country to the north of Bhooj is at first flat and sandy, but rising slightly becomes rocky and occupied by wide rolling exposures of flaggy ferruginous sandstone, red and yellow, hard and shaly beds, and some bands of hard fine, bluish gray, silicious grit. All these dip to the east by south, have a more prevailing red colour than the upper jurassic

division, rarely contain any fossils, and probably represent transition beds through which the indefinite boundary of the two groups might pass anywhere.

Not far from the temple, upon a low ridge due north of the city, and again on the right bank of the Kara (salt) river to the west, shells of *Potamides palustris* were found as usual in a fragmentary state lying loose upon the surface of the ground.

Kara river.

The much more shaly rocks which underlie those above described form the steep cliff banks of the 'Kara' river, one of which intersecting a small sandstone hill on the west side of the stream, not far from the temple to the north-west of Bhooj, shows a section measuring 110 feet in height. The lower 40 feet of this is dark gray shales, which with a low southerly inclination extend up the stream for a long distance, and crop to the surface of the country about a quarter of a mile to the north. The shaly and flaggy beds along the stream are in general unfossiliferous, but one or two small winged pecten-like shells were found in them on the west side of the stream; and where this is crossed by the Dhosa road from Bhooj, a band of hard calcareous rock, associated with blue silicious compact grit, contained casts of *Pleurotomariæ*, and, in the concretionary shales beneath, others of small bivalve shells. Plant fragments are less uncommon, being observed in the greatest numbers near the ford from Bhooj to Ruttria, southward of a place where the rocks are intensely contorted and crushed for a short distance, and traversed by peculiarly brecciated and other dykes of lava-like trap, the walls of which show, as is often the case, considerable alteration. One of the intrusions here is most irregular, and encloses massive blocks of hardened shales. The upper part of the river banks at this place are formed of an indefinite rubbly kunkury deposit; and on the west side, of a deep red, ferruginous, horizontal layer, looking like a recomposed or newer rock than the jurassic beds about this neighbourhood.

West of Bhooj.

To the westward of Bhooj the plain becomes narrower, the ground rising gradually from the sandy tract at the base of the Charwar hills northwards by scarped slopes to the elevated tract called the Kootabun and the flat-topped plateau which lies between the Kara river and Wurrar hill. The rocks are all of the coarse, white, red, and other varieties of the upper group.

Ruttria.

A small trap intrusion of the ordinary augitic character to the south of Ruttria has included and apparently altered a mass of white sandstone which forms a projecting crag. As it were enveloping this crag is a quantity of unctuous purple, greenish and white saline rock, resembling an earthy lava with white irregular amygdaloid specks; it occurs again at the east side of the intrusion where the junction with the jurassic sandstones takes place, and is almost, if not perfectly, identical with the volcanic portion of the sub-nummulitic rocks of many places. At Kalianpoor near another intrusion a loose rubbly lateritic looking rock with obscure relations occurs. A larger intrusion forms a conical hill to the southward, and at Gowmuck to the west, the hill, overlooking a sacred spring, is capped by coarse sandstone, in places columnar, and with veins and knots of the red sandy looking lava trap. This place is crossed by 'ramps' or reefs of silicious rock running north of west and east of north, and sand, apparently drifted, is heaped on some sides of the hills to an unusual height. Similar 'reefs' occur in the neighbourhood at Mankooa.

Kalianpoor.

Kooarkee.

A small hill of intrusive trap occurs at Kooarkee to the north-north-west, and another, the basaltic trap of which is magnetic, between it and the conspicuous peak of Kundwinga, the summit of which is also formed of intrusive trap.

In the valley between the last named intrusions, a thick band of shales is seen below the rocks of the plain faulted along a north-east

line against the coarse, white, upper sandstones for a little distance. The rocks to the north of this place having an intermediate or lower aspect, they have not been included in the upper group. Between Kundwinga hill and Kanpoor the upper sandstones roll in an open curve over an axis having a slight westerly inclination. To the south the plain is sandy, and in a north-west direction, open rocky ground, over which sandstones and shales undulate, is dotted by small hills of intrusive trap, or else crossed by dykes which seem to have, as it were, strengthened the sandstones sufficiently to cause the occurrence of these elevations. Some nearly horizontal beds of sandstone form a small flat topped hill at Kanpoor, and another near it, while some hillocks slightly above the sandstone plain at Mujull are crossed by a strong north-west basaltic dyke. Lying further west are the extensive ruins of Poorugud, said to have been destroyed by the earthquake of 1819. Much of the building, however shaken, is still standing.

Kanpoor.

To the south and south by west the hills of Rojla and Drabwa rise abruptly from the plain, the former somewhat of a ridge, the latter a flat topped hill with steep, or in places precipitous sides and an elevation of 400 feet. Both of these hills are capped by strong coverings of trap, which may either be intrusive, or have formed portions of one of the thick early flows of the stratified trap series. That on Drabwa is dark, basaltic, and magnetic, sometimes rudely columnar, and, being in places coarsely crystalline, when weathered it much resembles a dark syenitic greenstone. It rests upon the white sandstones and ferruginous beds of the upper jurassic group, which stretch everywhere beneath the adjacent plains and enter the sinuosities in the boundary of the bedded traps.

Rojla and Drabwa hills.

On Rojla hill east the trap is also basaltic, but was not observed to be columnar, while the stratified traps covering the higher ground of

which Rojla hill west forms a part, rest on a thick deposit of infra-trappean grit similar to that of Bhoojia hill; it is inconstant, not appearing everywhere along the escarpment of the traps, and if unconformable at this place does not seem so.

Infra-trappean grit.

The portion of the central plain east of Bhooj does not afford good data from which to calculate the local thickness of the upper jurassic group. This, however, probably much exceeds 1,500 feet.

Kukurbit.

Northward of these Rojla hills lies the small village of Kukurbit, by far the finest locality found in Kutch for the terrestrial plants of the upper jurassic rocks. The neighbourhood presents such sections as are to be seen elsewhere in these beds, with the usual kinds of white sandstone and ferruginous layers, and the beds of gray shales which may occur anywhere among these upper rocks.

In some gray flaggy shales of slight thickness overlying more sandy shales and light coloured sandstones just north of the village, where a country road descends the right bank of the river, the fossils occur in profusion, fractures parallel to the planes of stratification exhibiting their impressions, matted and interlaced together. They include several varieties of *Palæozamiæ, Taxodites (?), Cuninghamites (?)*, carpellary scales *of Conifers*, inflorescence of Cycads, *Cycadeous stems, Tæniopteris, Pecopteris*, seeds and stems* without a vestige of anything besides plant

* The following fossils were found at Kukurbit by Mr. Blanford—(*vide* Paper on Kutch already quoted):—

Cycadeæ ...	*Palæozamia Cutchensis*, Morris, very abundant.	
,, ...	,, *acutifolium*, ditto.	
,, ...	,, *Bengalensis*, Oldham.	
Coniferæ ...	*Brachyphyllum* ? sp.,	common.
,, ...	*Taxodites* ? sp.,	new.
	Small Walchia-like stems	(perhaps *Lycopodites affinis*, Morris).
Filices ...	*Tæniopteris*—	sp., fragmentary (may be *T. ovalis*).
,, ...	*Sphenopteris*	? sp., common.

remains, nor any proof that they originally grew at the place where they became fossilized or otherwise in its immediate vicinity.

There is nothing in the adjacent rocks nor in their fossils to fix the narrow zone of these fossils as one which might be elsewhere recognised, and even if hopes of this could be entertained, calculations would probably be nullified by the occurrence of several small north-north-west faults or slips which cut out the fossil bands and one larger dislocation, which, striking north-25°—30°-east was traced from near the same place for some distance, crossing the river obliquely with strong nearly horizontal sandstones overlying white and gray shales and brown flags on its south side, and similar but more shaly beds on the north, dipping to the west at 10°. The fissure is 3 yards in width, partly filled with crushed shale and partly by a 4 feet dyke of purple trap or concretionary amygdaloidal lava. In other places the same fissure contains ordinary gray intrusive trap. The neighbouring country is in places rocky, in others covered by heavy sand, and the fossiliferous beds could not be traced for any distance.

To follow this plain further westward would leave behind so much ground undescribed that it will be better to return to the Charwar and Katrol range, carrying its description westwards to the country south of the Rojla hills.

SECTION 7.—THE CHARWAR AND KATROL RANGE.*

This range evidently owes its origin to a fault accompanied by violent dislocation of the strata along its northern foot, combined with a complicated anticlinal structure, the fault having permitted a general subsidence of the nearly horizontally-bedded rocks of the plain to the north, and the anticlinal curvature, with undulating axis, to the south, aiding the beds on that side to assume the hilly form.

The Charwar and Katrol fault.

From an inspection of the map it will become evident that the amount of displacement caused by this fault must equal the maximum height of the northern escarpment of the range, formed almost entirely of lower rocks, plus the thickness of the upper group to the south, together with that of a portion of the super-incumbent traps represented by their outliers immediately north of the fault.

Its throw.

The unconformity between the traps and the jurassic groups, rendering the thickness of the latter to some extent uncertain, affects the accuracy with which the amount of throw can be stated, but this may be fairly estimated at 2,500 feet, supposing the lower part of the jurassic rocks to be an extension of those to the northward.

At the eastern extremity of the Charwar and Katrol range, the ground is low and undulating, with a few small peaks, the highest hills lying south of Anjar and being connected rather with the Dora Hills by broken and ridgy ground.

Vicinity of Anjar.

The plains south-east, east, and north-east of Anjar are occupied by alluvium and some underlying deposits, consisting of mottled red and

* This and its extension to the west is called in Captain MacMurdo's writings the Lukhi chain, a name, however, which we have never heard applied to it in the country. The detailed description of its eastern portion is mainly taken from Mr. Fedden's notes.

white nodular kunkury clays and rubbly gravels seen in the shallow nullahs, and, although unfossiliferous, believed to belong to some of the higher members of the Tertiary group.

From underneath these beds, near the flanks of the trap hills, south of Anjar, purple volcanic amygdaloidal breccia and lateritic deposits, similar to those of the sub-nummulitic band, occasionally appear. They are well exposed in the stream near Megpoor and are overlaid by conglomeritic deposits, apparently derived from the waste of these beds and the underlying traps, the latter here presenting pale grey and decomposed varieties.

Trap outlier.

North of Anjar is some low-rising ground forming a large outlier of the stratified traps, here in general much decomposed. They seem to have been bent into an open anticlinal curve, as the overlying laterite appears on both sides along the edge of the outlier, and also forms a couple of conspicuous conical peaks upon it, which, though visible from a great distance, are only about 100 or 130 feet in height (above the surrounding lower ground).

Calcareous conglomerates, probably the representatives of those already mentioned as overlying the lateritic group, are seen horizontal at the village of Warsameree, and dip to the north at 20° near Sutapur on the north side of the supposed anticlinal. At the latter place they are underlaid by some 50 feet of the faintly mottled thick earthy clays, having a similar inclination.

Plain west of Anjar.

West of Anjar the country is occupied by sand frequently arranged by wind so as nearly to envelope any projecting pieces of rock. It is confined to the upper jurassic ground which is terminated to the south by the well-marked basal escarpment of the bedded traps.

Close under this escarpment, near the villages of Seedoongra and Nangulpur, there is a long irregular line of fissure, occupied partly by a large trap dyke and partly by a reef of the usual silicious compact stone resembling "fault rock."

Dyke.

The country west of the outlier abovementioned becomes hilly, a sharp anticlinal ridge curving from east and west to east-south-east. The rocks of this ridge and its neighbourhood are of the ferruginous black, red, purple and yellow, coarse and finer sandstones, with flaggy beds belonging to the local upper jurassic group.

Anticlinal east of Katrol.

The steepness of the angles of the dip, their varying directions and the occurrence of ramps beneath the northern slopes of this ridge, lead to the conclusion that the great fault to the westward continues through this disturbed ground.

South of the ridge the rocks become contorted, dipping in various directions, generally away from a remarkable circular valley called the Surr Tullao, about 2½ miles broad; the narrow outlet of which to the east having been dammed up, the whole of the basin becomes flooded by the rains.

Surr Tullao.

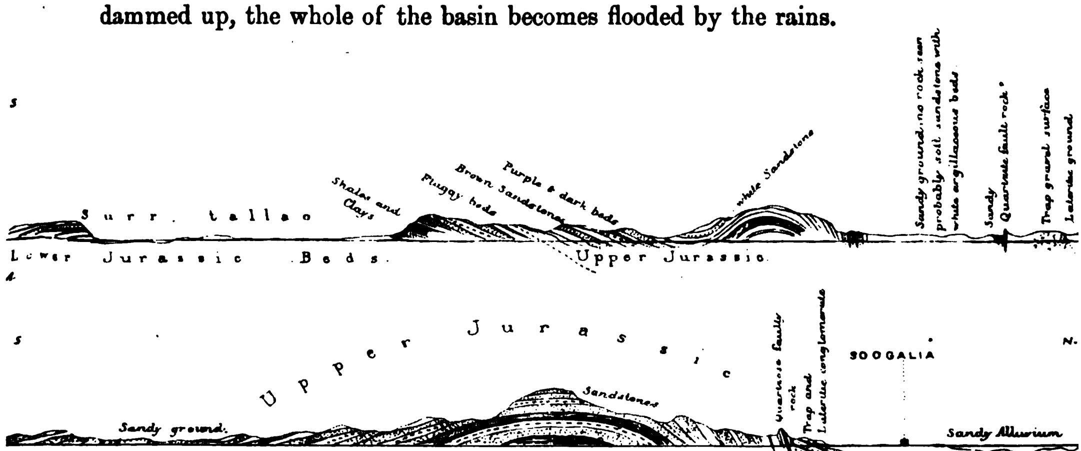


Fig. 14.—Sketch sections, south from Soogalia, eastward from the Surr Tullao; and from Rutnal, across the Surr Tullao.

This hollow is occupied by the soft sandy clay and gypseous shales of the marine jurassic group underlying compact flaggy sandstones. Near the middle of the Surr are some great masses of compact, thick-bedded, grayish-brown sandstone, with carbonaceous markings. A strong dyke of basaltic trap is well seen on the western side of the Tullao, the remarkable form of which is due to denudation of the softer beds. The relative positions of the neighbouring rocks will be seen by referring to the annexed sketch sections. In the superior jurassic beds of the above sections, further to the west, some fine specimens of *Palæozamiæ*, &c., were found near the village Chubruk, and again in the vicinity of Loharea to the south-west—at both places in coarse ferruginous sandstone.

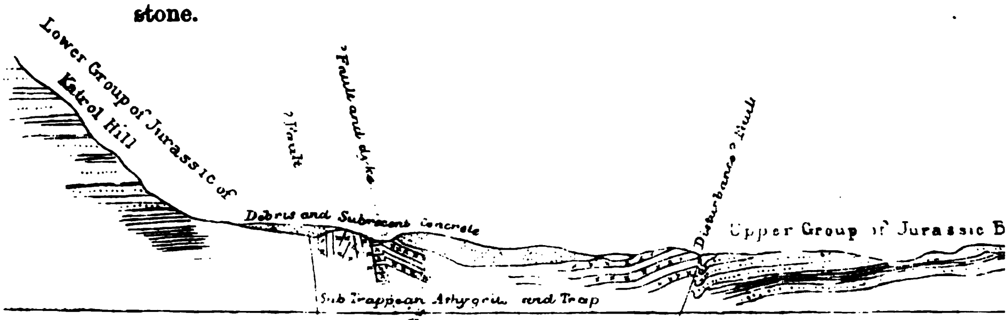


Fig. 15.—Sketch section, north base of Katrol range, south of Boojooree.

Westward of the large trap outlier already mentioned, a considerable sized detached portion of the same bedded traps is faulted against the superior jurassic rocks, not far from the eastern base of the Katrol Hill, the most lofty summit of the range. This outlier has a gentle slope to the south by east, its thickness increasing in that direction. It rests upon the higher beds of the upper jurassic group, also inclined in nearly the same direction at angles of 5° and 8°.

Trap outlier near Katrol.

The trap is of the usual dark basaltic kinds, often columnar, the prisms being small; and the higher jurassic rocks seen in the scarp to the north consist of soft sandstones, parts of which are coarsely

granular and gravelly, with a white felspathic matrix. Oblique lamination prevails, thick pink and yellow-striped sandstones forming the base of the escarpment, while just beneath the trap is a hard bed of black ferruginous conglomeratic grit, the section being somewhat similar to that in the neighbourhood of Buchaoo.

At the eastern end of the outlier, the ground is much disturbed by faults, and some small representatives of the lateritic group occur near the village of Rutnal. In this neighbourhood much silicified fossil wood, mostly rolled and polished, was found in the surface soil; it has probably been derived from disintegration of some tertiary rocks which have disappeared from this locality.

From the small detached trap hill west of the village looking towards Katrol, the faulted position of the trap is fairly seen.

Fault.

On the south side of the outlier is a rugged and irregular wall of 'fault rock,' marking a deflection in the great line of fracture north of the Katrol range, and the jurassic beds are either vertical or dip at higher angles towards the fault.

Conspicuous hills.

After Katrol, Joondia and Urrooa are the two most conspicuous peaks in this neighbourhood. They are conical hills, situated on the axis of an anticlinal in the lower jurassic rocks. From Urrooa, the most lofty of the two, several trap dykes radiate in different directions, the fissures of which are sometimes occupied by trap and sometimes marked by strong ridges of quartzose rock, apparently altered conditions of the adjacent beds, this being chiefly observed along the courses of the two large ones running towards the south. In these also a triple arrangement is observed, the centres being occupied by ordinary grey trap, with the soft purple lava-like variety on either side probably marking later periods of eruption.

Joondia hill, though smaller, presents a precipitous face to the north, exposing white gritty and felspathic sandstone, parts of which are columnar in regular hexagonal prisms.*

Columnar sandstone.

A large trap dyke cuts through the hill, altering the adjacent rocks, and underneath the columnar sandstone some decayed trap appears to have been intruded, the bed beneath which is so highly altered as to have become a kind of hornstone.

Escarpment of the stratified traps.

That portion of the trap escarpment south of the Katrol range forms a well-marked feature when seen from a distance, the unconformity to the jurassics being apparent, while on detailed examination the junction is found to be much overrun with local debris and sub-recent calcareous concrete, which also occurs at higher elevations near Keroee and other places. It is largely burned for lime.

Calcareous concrete.

In this neighbourhood the traps have a south-easterly dip and present alternations of concretionary solid and decomposed basaltic flows, with fine examples of columnar structure in the gorge of the Keroee stream.

Katrol Hill.

Katrol Hill gives its name to a portion of the range, has an elevation of about 550 feet above the plain to the north, and is the most lofty summit of the whole chain, the steep northern escarpment of which is very persistent to the west, though the heights gradually decline. Between the scarp and the plain to the north are some low hills which, west of Lair, form a subordinate parallel ridge. The principal range, like most of the others in Kutch, coincides with an anticlinal curvature of the beds.

* This occurs so frequently in the upper jurassic area as to suggest the possibility of its having formed the floor of a trappean flow, and it may here indicate a small outlier of the upper portion of the jurassic beds.

This has been removed by denudation along the northern side so as to form the scarp.

From the very summit of Katrol and the crest of the ridge generally, the rocks commence to take a southerly inclination, increasing as the ground declines until the foot of the hill is reached, when it rather abruptly becomes less, and in the open ground extending southward to the trap boundary, the upper beds of the jurassic series come in with very gentle, but still southerly inclinations.*

Northern escarpment of Katrol Hill.

The escarpment along the northern face of this hill in this neighbourhood exposes a strong band of shales in the lower part, with calcareous beds containing belemnites, overlaid by soft thick yellow sandstones, the summits being formed of ragged sandstones and shales with harder bands of calcareous, gravelly grit; some of the latter have layers of ferruginous nodules enclosing various *Ammonites*, *Belemnites*, and fragments of wood. Large specimens of *Ostrea Marshii* occur in one bed of calcareous grit.

At the north-east base of Katrol, not far from the village of Bowlee, the beds on the northern side of the anticlinal are well exposed, the section being as follows :—

'In the plain near the fault are soft sandstones, variegated and streaky, pinkish, with white blotches and specks; thickly-bedded, obliquely-laminated, horizontal or rolling, but close at the fault, they dip steeply to south towards the vertical white sandy beds on its south side. Just here there is a great crush, and the rocks are so soft and sandy that their dip or strike could hardly be traced, but a little further south the beds appear more regularly.'

* This open ground, though declining gradually to the eastward, in which direction its drainage might be expected to flow, is nevertheless crossed by several streams from north to south, and instead of following the general line of denudation in the softer jurassic rocks, these have excavated for themselves deep gorges across the broad belt of traps forming the Dora Hills.

Descending order.

	(Beds vertical to horizontal).	Thickness in feet.
KUTCH, UPPER JURASSIC.	x.—Crush and fault.	
	24.—Very white and felspathic, loose, rock, a mixture of coarse quartz gravel and fine sand (some of this quartz clear and transparent, rock-crystal): thickness to south from fault ...	125
	23.—False bedded soft sandstones, grits, and gravels, the quartz more or less angular; some runs very coarse. So indefinitely and falsely bedded that the strike is hardly determinable; the beds are probably vertical, striking east and west. In the first thirty feet of this there are several dark and yellowish brown shaly and crisp layers among fine pale fawn-colored sands	180 (beds 23–20)
	22.—Fine pale, soft sandstone	
	21.—Ferruginous layer with lumps of hæmatite, wavy, irregular	
	20.—White and various-colored sandstones ...	
	(Dip about 80° to N.).	
	19.—Sandstone beds more or less ferruginous, rough and gritty; honeycombed on weathered surface. Among these some yellowish brown flaggy shale with hard bands	300 (beds 19–15)
	(A slight disturbance in the section).	
	18.—False bedded and finely laminated sandstone shaly or flaggy, with (? worm) tracks, showing a central line	
	17.—Dark brown, purple, &c., gritty, irregular sandstone, with a run of coarse white pebbles of quartz and dark quartzite, passing down into—	
	16.—Dark gritty sandstone bed, full of annelid tubes, mostly vertical, but indefinite, purplish in color. Some of this rough-looking rock resembles laterite in its weathered aspect. One bed coarsely ripple-marked	
	15.—Hard dark sandstone and ferruginous grit, irregularly lumpy on the surface	
	14.—Variegated soft sandstones, shaly below ...	30 to 40
	13.—Dark, ferruginous, very coarse, gravelly band (white quartz pebbles)	30 to 40

		Thickness in feet.
KUTCH, UPPER JURASSIC,—contd.	12.—Dark, ferruginous, gravelly and gritty sandstones, false-bedded, parts coarse	30 to 40
	11.—Softer yellow sandstones, not well seen ...	
	10.—Brown and purple flaggy shaly layers with smooth surface and worm tracks	
	9.—Hard bed of brown and dark purple sandstone ...	
	(Section ascending a low ridge of rocky ground).	
KUTCH, LOWER JURASSIC.	8.—Gritty sandstones in which are fine pebbly beds and irregular runs of finer sandstone. The coarse granules of white quartz stand out on weathered surface	
	7.—Purplish, red, boley bands among fine-grained flags gravelly layers of small quartz pebbles alternating several times with finer sandstones and with rubbly partings	
	6.—Hard, rough, calcareous grits (fine grains of white or translucent quartz standing out on the surface). Some rubbly sandstones; coarse runs of white quartz pebbles in the upper part ...	200 to 250
	(Rocks dipping north, angle 70°, but decreasing to the south).	
	5.—Gritty sandstones, in which a fish tooth was found	
	4.—Flaggy and banded sandstones, more or less calcareous, among softer rubbly sandy shales. Wood markings in some of these layers ...	
	(*Note.*—These appear to be the representatives of the Katrol Hill beds, though neither *Ammonites* nor *Belemnites* occur in them here).	
	3.—Similar soft sandy shales and rubbly beds, with large red nodular lumps and geodes, many of which contain pieces of fossil wood. Their thickness is considerable, though not determinable here, as the angle of inclination is inconstant, becoming less and less; the ground is irregular and the outcrops indefinite ...	
	(These extend up to and beyond a ravine marked in the section a little north of Bowlee. There the beds are horizontal, and in the stream section are seen)—	
	2.—Loose, rubbly, yellow sandy shaly beds ...	40
	1.—Dark micaceous clay bands and argillaceous shales	50—60

Note.—Some large logs of fossil wood and a few fragments of reptilian bones were found near the village of Bowlee in a hard gritty sandstone, equivalent to No. 5 in above section.—F. F.

Infra-trappean beds, north of Katrol Hill.

A singular section is exposed at the north base of Katrol Hill between the higher jurassic beds of the plain and the lower group south of the line of dislocation.

The upper beds here, consisting of coarse, white, felspathic, variegated and brown sandstones, frequently conglomeritic, with some beds of shale, have a general dip to the south-30°-west at angles under 20°, and terminate suddenly at a line of disturbance, beyond which for about 300 yards occurs a strange assemblage of what have been elsewhere termed infra-trappean grits. They are generally very open and incoherent, but their trappean or coarse ashy aspect is quite as constant as their granular mechanical structure, some portions passing into sandstone or from sandstone into solid amygdaloidal trap. Towards the north side of their exposure they are distinctly stratified, dipping south by east at angles varying from horizontal to 12° or 20°. For some distance they become obscured by thick sub-recent concrete, adding greatly to the difficulty of understanding the section, but southward beyond this they are more trappean looking and decomposed, with gritty and earthy portions and the transition abovementioned. Some hard calcareous sandstone occurs here (much resembling that of Katrol Hill) either vertical or dipping at a very high angle to the north. South of it is a vesicular basaltic trap, perhaps a dyke, and the ground is again so obscured by sub-recent rock and debris from the hill that nothing further regarding the arrangement of the rocks can be made out. Both ends of this section appear to be in faulty ground, and it is probable that the line of the great Katrol fault here comprises more fractures than one, the intervening spaces being occupied by some of the infra-trappean rock which probably once extended over the Katrol summit.

South side of Katrol range.

The rocks on the south side of this portion of the range are, generally speaking, coarse sandstones and compact flags, with shaly partings, one bed containing casts of small bivalve shells.

To these succeed the thick brown and light-colored, ferruginous, mottled sandstones of the upper group, becoming more shaly above, with plant impressions, and underlying the usual coarse white felspathic and conglomeritic sandstones. These disappear to the south beneath the stratified traps.

West of Katrol Hill.

West of Katrol the range is traversed by several trap dykes, some having the triple arrangement already mentioned, indurating and otherwise altering the adjacent rocks. Still lower beds than have hitherto been described, including several highly fossiliferous bands, are exposed on the northern side of the range.

The following section, taken from the fault south of Boojooree to the crest of the range, will show the succession of the rocks:—

Natural or descending order.

(General dip south at low angles).

14.—Yellow rubbly sandstones, with shaly and flaggy bands, marked by large worm-tracks(?) with central line, and some thin layers crowded with minute seed-like bodies resembling *Cypridina*.

Note.—(A large basaltic dyke (x) crosses these beds, bearing south-east, altering the shales in its vicinity).

13.—Softer yellow, argillaceous beds, with fine thinly-laminated sandstones; lower part with thin earthy crisp layers.

12.—Coarse calcareous grit.

11.—Soft shales with thin harder bands. Fragments of *Ammonites* about the surface.

10.—Rubbly yellow sandstones, with annelid tubes and impressions of wood.

9.—Red lumpy concretionary bands among softer yellow beds. A few *Ammonites* and fossil wood.

Dip south, angle 35°.

8.—Dark yellow clay, decomposing, with small green flakes and red specks.

7.—Yellow earthy gypseous and dark finely-laminated shales, with hard bands of nodules (bored by molluscs) resembling conglomerate. In these bands occur *Ammonites*, large *Belemnites*, *Trigonia*, *Pecten*, n. sp., species of oyster of the type of *Ostrea rostellata*.

6.—Rubbly argillo-calcareous bed in gypseous clays, with red lumpy concretions.

5.—Hard, dark, coarse sandstone, false-bedded, parts red and lumpy, sections of large bivalves, *Belemnites* deeply grooved to the point, *Trigonia costata*, small *Pecten*, &c.; shells more abundant in upper part.

4.—Gypseous clays, with flaggy and rubbly sandstone, red lumps and purple bands; *Belemnites* strongly channeled, casts of bivalves, and small *Annelid* tracks.

3.—Light-grey sandstone, thick-bedded, hard, calcareous portions, with glistening cleavage planes on fractured surface; black where exposed.

2.—Gypseous clays and yellow earthy shales. A few *Ammonites* of undetermined species, probably Oxfordian, coated with gypsum.

1.—Yellow sandstones and grits, more or less calcareous, also purple conglomerate beds nearly vertical. *Ammonites, Belemnites, Terebratulæ, Pleurotomariæ,* &c.

Note.—It is possible that Nos. 1 and 2 in the above section are portions of Nos. 6 and 7, which they closely resemble, let down by a fault undetected in the soft shaly beds. Fossils were most abundant in Nos. 5 and 6 and in certain calcareous and conglomeritic bands in the clays above. The pseudo-pebbles that form these bands are of tough light-colored clay, often penetrated by cavities of *Pholadidæ* or some boring molluscs.

About this horizon to the westward, a shale zone occurs, containing a new species of *Ammonite* allied to *A. Pottingeri,* below which are other fossiliferous beds, with *Terebratula, Rhynchonella, Belemnites,* and small *Ammonites* very common. The sandstones of No. 3 are not at all unlike some of the upper series of the jurassic: a hard bed, occurring in the middle, has a peculiar crystalline appearance reflecting light from cleavage planes on the fractured surface; this weathers black where exposed. The whole section comprises a thickness of about 1,500 feet of strata. The continuation of this section upwards may be traced near Juddoora village, two miles to the west, where No. 14 of the above list is exposed at the top of the ghât, and overlaid at the village by a hard, calcareous grit containing a few *Belemnites* and spines of *Echinoidea.* To this succeeds a thick group of shales, with nodular and gritty bands, containing a few *Ammonites, Haploceras tomiphorum,* and *Aspidoceras Apenninum,* and these pass upwards into the usual unfossiliferous thick-bedded, yellow and pinkish sandstones, with flaggy and shaly bands, that underlie the more characteristic beds of the upper division.

Portion of escarpment south of Bhooj.

Still further west the lower jurassics just south of the fault become much contorted; the escarpment precipitous and its crest formed of the upper group,

extending with low southerly inclinations through the country in that direction, until overlaid by the stratified traps, the rocks presenting the same varieties as those already detailed. South of Juddoora some good specimens of *Palæozamiæ* were found in the white sandy shales of the upper group.

Khirgreea Hill.

Rising from the broken ground formed of these rocks is the conspicuous rugged hill of Khirgreea, an outlier of the traps to the south. At and near its base the sub-trappean grits are seen, with much of the appearance presented by those of the Kokma Hills beforementioned, and the upper part is formed of strong dark magnetic basalt, which may have found its way to the surface at this spot. One or two considerable trap dykes run from this hill towards the bedded traps to the south, but were not traceable within its boundary.

Trap escarpment near Khirgreea Hill.

The escarpment of the stratified trap here reaches its greatest elevation, and at one spot its base is formed of a succession of trappean ashy grits and more sandy infra-trappean beds, having a thickness of 20 feet. These, however, do not occur generally along the scarp, the lower portion of which is often composed of the jurassic beds.

The Dora Hills.

The Dora Hills here present three or four low parallel east and west scarps among broken hilly ground, formed by the alternation of harder and softer trap flows, the latter in the lower part of the series frequently containing agates, zeolites, and geodes, lined with rock crystal in great abundance. In consequence of the flows having a general southerly dip at from 3° to 5°, the terraced and tabular appearance so prevalent in the trap area of Central India is not observable in this locality, though the traps are in other respects identical, consisting of the same varieties of basaltic and amygdaloidal doleritic rocks.

The thickness of the Deccan trap formation in these hills may be on the average 2,500 feet, which is in excess of that given by Mr. Blanford, as cited before, but the map which he used was considerably out as to distances, and the rocks where he crossed were much narrower in extent than as they are exposed here.

Thickness of traps.

Near the village of Sairat, about a mile west of Khirgreea, a slight anticlinal curvature of the jurassic beds is seen in the neighbouring stream section, causing an exposure of some beds lower than those which overspread the country eastward. They consist of shaly clays with nodular bands, flaggy sandstones, underlying finely-laminated shales, with a few carbonaceous streaks. The latter on the north side of the anticlinal appear to be faulted against the coarse white grits of the upper group, which are sharply contorted and abut against an outlier of soft infra-trappean grit, here containing numerous fragments of fossil wood replaced by impure carbonate of lime. Just south of the village it seems to be more trappean in a small hillock which is capped by thick-bedded, black and red, ferruginous sandstone.

Neighbourhood of Sairat.

The lower portion of the hillock is traversed by veins or reefs of tough calcareous grit, which has a glistening fracture.

Further down the stream near Barapoor, the rocks are again much disturbed and traversed by irregular dykes of purple and brecciated lava traps, some of which do not appear to have reached the surface.

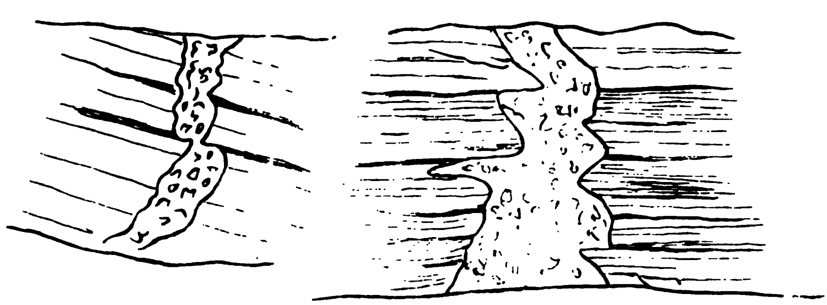


Fig. 16.—Lava dykes in bank of stream south of Sairat.

Near this, above the right bank of the stream, the upper beds are again greatly disturbed and faulted, and patches of the infra-trappean grits re-appear and can be traced nearly down to Khaira. Hereabouts the usual upper jurassic rocks prevail, and the height to which they ascend in the face of the trap escarpment to the westward exhibits the irregularity of the surface upon which its flows were laid down.

Kaira.

On the north side of the old fort of Kaira a small patch of rough, coarse, ferruginous sandstone, two or three feet thick, resting upon some of the soft open sandstone of the upper jurassic group, was found to contain smooth, glazed cylindrical casts of large monocotyledonous plant-stems, resembling some species of *Calamite*.*

Inter-trappean.

Near the conspicuous temple south of the town within the trap area, a small exposure of sedimentary inter-trappean rock was observed, consisting of tough, compact, flaggy shale, impregnated by green earth, and containing a narrow band of compact or finely-crystalline yellow limestone, brecciated in places, enclosing small fragments of finely-amygdaloidal zeolitic trap. It has no great extent, is but a foot or two in thickness, and appears to be quite local. The amygdaloidal flows in the neighbourhood are indefinite and irregular, and some compact basalt among them is porphyritic.

Charwar Hills.

The more lofty portion of the Charwar Hills west of the road from Bhooj to Mandavee is formed of the southern side of the anticlinal curve, which appears to have been broader here than usual, showing a steady dip to the south-east and south, which carries the lower beds under the upper Jura group of the neighbourhoods of Megpoor and Dysera. From the broken ground

* These have only been met with in one other locality far to the north-westwards, where their true position was extremely obscure. If they belong to the jurassic rocks, their more frequent occurrence might have been expected.

west of the latter village a strong trap dyke, varying in width up to 160 feet, extends northwards to the crest of the range.

Complication near the Mandavee road ghât.

Between the ghât on the above road and the village of Mankooa, in the plain to the north-west, the great Charwar and Katrol fault becomes checked, displaced, and complicated by the occurrence of numerous minor fractures, the effect of which has been to remove its general bearing about a mile further to the south, the lower rocks in this vicinity being greatly disturbed, contorted, and traversed by trap dykes and intrusions of varying textures and hardness. The largest of these occurs in the main line of fault and the lower beds in contact are intensely altered.

Disturbance near the ghât on the Mandavee road.

For some distance on each side of the Mandavee road along the northern base of the Charwar Hills, the fossiliferous beds of the lower series occur among the contortions just south of the fault. They contain numerous *Terebratulæ, Ammonites, (Stephanoceras) tumidum?* more rarely, *Ostrea* (undeterminable), *Belemnites* (undeterminable), *Cucullea virgata, Trigoniæ, Pleurotomariæ,* and others, chiefly bivalves.

Recess in the hills south of Samtra.

South of Samtra the hills recede in that direction and a broad space is occupied by broken ground with some deep ravines. The lower beds are still much contorted along the south side of the fault, which is clearly traceable, running nearly east and west, while those of the upper group on its northern side undulate at low angles. A strong dyke of light brown porphyritic trap, running from the hills northwards, shows several dislocations along its course, and the various alterations of shale and sandstones in the country on each side of it are the same as usual in the lower portion of the jurassic series.

Succeeding to these, hard, gray calcareous grits dipping to the southward form a craggy ridge through which this dyke could not be

traced. To the southward still, the upper beds forming rugged ground dip steadily at low angles beneath the traps.

Near Rampur.

In the neighbourhood of Rampur, several strong quartzose reefs traverse these upper beds, and the following section was observed at the scarped junction of the jurassic and overlying trap formations:—

Descending order.

	(Dip to south, low angles).	ft.
	5.—Sub-recent gravelly deposit conglomeritic ...	6 to 8
STRATIFIED TRAPS	4.—Decomposed brown trap, parts laminated. The middle portion dull, dark, reddish, very amygdaloidal, containing zeolites and green earth; lower part also amygdaloidal	20
UPPER JURASSIC ROCKS OF KUTCH.	3.—Gritty, gravelly sandstone, highly impregnated with green earth, giving it an emerald green colour, some parts pink and white ...	12—14
	2.—Intercalated basalt, probably intrusive ...	about 6
	(Talus concealing the rocks for a short distance).	
	1.—White, soft, sandy and gravelly beds of the upper jurassic group of Kutch.	

Peculiar breccia.

In the hollow on the left bank of the river, a little to the south-west of the above section, a peculiar brecciated deposit occurs, which may have been the basal portion of the trap series. It is formed of scoriaceous lumps of trap, differing in texture, mixed with sand, clay, and gravel, the whole apparently cemented by zeolitic infiltrations.

Stratified traps.

The stratified traps south of this place show another strong escarpment running in an east and west direction. They consist generally of the usual gray amygdaloid variety, with some purple bands, the weathered condition frequently showing harder projecting lumps. Nearer to the base of the series they contain chalcedony and zeolites, and compact basaltic flows were more frequently observed. All dip at low angles to the southward.

Saat Mouri Hills.

To the westward of Rampur, a long north-westerly dyke forms a chain of hills called by the natives '*Saat Mouri*,' from having seven conspicuous summits. The strike of this dyke is somewhat irregular, and its width varies up to 25 feet or more. Between some of the hills the trap disappears, and a reef only is found similar to the runs of quartzose rock so frequently seen in the jurassic ground. The trap of this dyke is compact, dark-grey and augitic, in some places columnar, the columns being transverse to its direction and horizontal. Its termination near Rampur bending to the southward is plainly visible, standing out from the amygdaloidal trap flow which it there crosses.

West and north of the Saat Mouri dyke.

Westward of this dyke, upper jurassic beds of the usual kinds occur, but in the country to the north, light-coloured sandstones, with some thick shales, were taken to represent the transition portion of the lower group. Here some large intrusions of compact and crystalline trap, partly in the strike of the Saat Mouri dyke, cross the disturbed beds, obliquely rising upon some low hills, and in places include or are capped by whitish indurated sandstone.

Gorkur Hills.

In the country lying between Nambye, Koorbya, and Deysurpur, a strong group of hills rises to the west of the recess in the Charwar range south of Samtra. They were spoken of as the 'Gorkur Hills'; but as it was uncertain that this name was generally known, it has not been introduced upon the map. These hills form a most complicated piece of ground, traversed by innumerable trap dykes and intrusions between the beds. The latter, consisting of alternations of shale bands and hard massive, white and grey, silicious grits, undulate much, but have a general dip to the south-west and west-south-west.

Complicated dykes.

In the vicinity of Nambye blue and grey grits and dark shales are intensely cut up by intrusions of dark-grey basaltic trap, a fresh one occurring within every few yards at one spot, sometimes more or less vertical, and sometimes inclined with the bedding of the shales. These lower jurassic rocks are frequently highly altered and present on fractured surfaces a glistening aspect in certain positions, when the light is reflected from latent planes of crystalline structure invisible in other directions.*

Gorkur Hills near Koorbya.

Further to the north, near Koorbya, some dark shales occur in wells close to the village. Below them apparently, to the eastward, ascending the slopes of the hills which incline with the stratification to the west and south-west at 5°, are light greenish-grey, ashy-looking beds, among which are some resembling limonite overlying coarse red sandstone with impressions of wood. Under these sandstones come conglomeratic and gravelly rusty beds, with softer, compact, greenish-grey, earthy sandstone, which weathers into concretionary forms and overlies more gravelly sandstones with whitish flags and purple layers. Olive sandstones with black carbonaceous (?) markings and scattered quartz grains underlie these and pass down by white, red, and rusty alternations into a mass of black and grey, coarse, micaceous, felted-looking shale of some 150 feet in depth, containing only some obscure plant fragments.

These shales abut against an intrusion of solid, dark, coarse and finely-crystalline, basaltic trap, varying in width up to 150 yards.

Northwards of this a small peak is formed of more easily weathered trap, the lower portion of which is intercalated between the sandstones

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* A similar structure has been observed in some of the lower jura beds of the Charwar range elsewhere, less closely associated with igneous intrusions. The dykes, &c., of this country being impossible to represent in detail, a general diagrammatic indication has been resorted to upon the map.

and shales, dipping at a low angle to the west, and forming that side of a little valley in the bottom of which thick black shales again appear. From beneath these some strong light-colored sandstones crop out, and another mass of hard basaltic trap from 200 to 300 feet in width runs along the strike of the beds as if intruded between them. Coming out as it were from beneath this trap and sandstone band is a strong zone of hard, white and grey, quartzose sandstone, with largely conchoidal fracture, pieces of which ring when struck by the hammer. It is from 300 to 400 feet thick, and rising on the hillside forms the crest of the range for some distance, dipping to the south by west. Blocks of it, varying in size from ordinary boulders up to the dimensions of small houses, lie scattered about its escarpment, broken off the outcrop by the disintegration of some thick shales upon which it rests. In these black, blue, and grey shales, another strong, but much thinner, band of basaltic trap, softer at its upper and under sides, dips westward with the shales, which here form the breast of a steep scarp along the eastern side of the hills. Besides the intrusions noticed, some smaller dykes were observed and doubtless there are many more. The thickness of this portion of the lower beds, from the escarpment westwards to Koorbya, including the traps, may amount to 1,500 feet. They appeared to be all but unfossiliferous.

Following the beds of this range northwards to the great Charwar and Katrol fault, they are found to become vertical in places close to it; forming high hilly ground along its south side for some distance. The traps abovementioned are not traceable in the plain north of the fault where the coarse, red and white upper Jura beds are nearly horizontal or dip gently towards the hills.

Trap, south of Drabwa Hill.

South of Drabwa Hill a thick mass of greenish-olive weathered trap, associated with muddy, ashy-looking shales, forms some hilly ground extending towards the

base of Nunnao. The same complicated alternation of intrusive and intercalated appearances prevails among these traps, the most interstratified looking portions of which are seldom far removed from cases of distinct intrusion; so that lacking clearer evidence of their being contemporaneous, while everything along this portion of the great fault indicates intense disturbance and dislocation of the beds, it is safer to suppose that the igneous materials have found their way between the disturbed strata where alternation is now apparent.

Beds of the Kutch Upper Jura group, south of Drabwa Hill.

The Upper Jura beds south of Drabwa Hill undulate nearly horizontally, and a mass of white, silicious rock forms a knoll just at the foot of the hill in which no decided dip could be traced. Westwards towards Nunnao these upper beds become contorted with high northerly dips and some sharp anticlinal curves. Through this disturbed country the great Charwar and Katrol fault seems to strike directly for Nunnao Hill.

Nunnao Hill.

This hill of Nunnao is a nearly circular, lofty, dome-shaped mass of trap, having an elevation of 770 feet and a basal circumference of more than 3½ miles. It was probably the source of some of the neighbouring stratified traps, but, its height exceeding greatly that of their lower flows, some of which approach it nearly, eruptions issuing here would be more likely to have formed portions of their higher and newer beds. However this may be, no direct connection at present exists between such flows and this hill as a source, nor has it at all the appearance of being an extinct sub-aërial volcano. If it were ever surrounded by an envelopment of scoriæ, dust and lava, these have all been swept away by denudation, and little besides the core remains. This is not homogeneous, some external portions being of soft, easily-decomposing, ashy traps, and others of intensely hard intrusive basalt projecting in the form of crags, columnar

in places and extending continuously from base to summit on the south side of the hill (? dykes).

Under the north brow a mass of pale purple, amygdaloidal, steatitic, lava-like rock, one hundred yards in length, rests patchwise upon the jurassic sandstones at its base; it may be from 10 to 20 feet in thickness, abuts in one place against yellow, soft sandstones, along a line of apparent fault which would just clear the eastern side of the hill, and is in places thickly interlaced with strings of hæmatite. This rock exactly resembles that found near Ruttria, west of Bhooj, and many similar ones in the sub-nummulitic group. Its mode of occurrence here is somewhat concealed by debris from the hill. Within some large concretions which it contains we find a beautiful pale lavender-grey color.

Lava trap outlier north of Nunnao.

Near the southern end of the exposure grey amygdaloid and bands of red sandstone are confusedly associated in a mass, having somewhat the nature of this outlying patch, and some of the decomposed soft ashy trap, found also on the east side of Nunnao,* here seems to conform to an east and west arrangement of the sandstones and is traversed by peculiar silicious seams or veins.

Just at this spot a reef of red, brecciated rock, resembling fault rock, crossing the upper jurassic or plant beds at the base of the hill, strikes to the westward by south along a line of white sandstone crags, the southern edge of which is of the same silicious character.

South of these craggy hills the upper sandstones contain some dark and pale greyish-purple shales, with black carbonaceous layers, one bed of the shales being

Fossil plants north-west of Nunnao.

* It is perhaps possible that these soft, trappean, decomposed-looking rocks were formed by an early eruption from the site of Nunnao, or are remnants of some of the lower trappean flows which may have extended easily to beyond this locality previous to the extrusion of the trap which forms the hill.

full of branching fern-like plants, of which as they ramify through the rock it is impossible to obtain good specimens. The beds dip north at 5° to 10°, and the fossils are similar to some occurring near Jooria in a white argillaceous rock.

East of Roha.

Westward of this the upper jurassic ground contrary to its usual habit forms hilly spurs projecting into the trap area, the latter occupying the adjacent low ground. This unusual occurrence is almost entirely confined to the localities indicated, east and south-east of Roha, where the sandstones are in places highly silicious and compact.

Rakal Hills.

The Rakal Hills south-west of Nunnao are formed by some of the lower flows of the bedded traps, with general inclinations in the direction just mentioned. As usual, their boundary presents more or less of an escarpment, but this seems to have resulted rather from the difference of texture between the trap and underlying sandstones, than from any connexion between the inclinations and the denudation of the flows, both conditions having elsewhere combined to produce the boundary escarpment and outlines of the trap area.

South of Koorbya.

In the valley of the stream which passes Seesaghud, some basaltic trap appears to have been intruded between the bedding of hard, quartzose sandstones south of Koorbya. These are overlaid in the river to the west by a thick band of blue and grey, felted-looking shales,* with olive harder bands, succeeded by red rugged and purple coarse and fine sandstones, conglomeratic beds and shales. Fossils are very rare in these, but a

* The term "felted-looking" is applied to sandy shales with a very minute oblique lamination, often lenticular, which produces a matted appearance in section. These beds are generally very tough.

Belemnite was found in one of the river pebbles. The general dip is westerly.

Neighbourhood of Seesaghud.

Further down the stream the low dip comes round to the south, and strong red and purple sandstones, with highly ferruginous beds, some wholly composed of vertical cylinders like fulgurites, underlie purple and light colored, more flaggy rocks, in which fine-grained, pure white beds become numerous. In these beds a brown carbonaceous shale, full of ordinary plant fragments, and containing a few fragments of *Taxodites*, occurs.

It was on this horizon probably that the search for coal mentioned by Colonel Grant as having been made near Seesaghud was carried out, but the exact spot was not discovered. The situation of the beds with carbonaceous shale and *Taxodites* having regard to those below, is, it will be observed, very similar to that of the Trombow coal locality.

White and ferruginous, yellowish and gravelly sandstones of the usual upper character occur in the country about Seesaghud, and are crossed by a double parallel line of fault on the road from Verani to Seesaghud.

Reef and dyke.

The Killa or Fort of the latter town surmounts a peak of white sandstones traversed by a strong north-by-west reef, parallel to which, a little to the east, portions of an ordinary trap dyke are traceable.

The basal escarpment of the stratified traps passes close to the town of Seesaghud, the lower flows of this neighbourhood being amygdaloidal, with zeolites, agates and quartz geodes, locally very numerous towards Mhow. Southwards some more compact beds form a continuation of the escarpment mentioned as occurring in the trap area south of Rampur. This forms a well-marked feature for a long distance, but dies out further to the west.

Korikoba.

The upper jurassic rocks surround Deopur, forming a bay to the west, crossed by a basaltic dyke, and run in among the traps south of the very conspicuous conical peak called Korikoba, more than 300 feet in height, and formed of rudely-columnar basalt overlying 200 feet of soft infra-trappean grits.

West of Mhow.

Between Mhow and Mukkra denudation has exposed the upper sandstones within the general boundary of the traps, which are but thin for a short distance to the south, small inliers of the sandstone appearing in a few places. Eastward of Mukkra village a stream valley exposes a section showing more irregularity of the surface upon which the traps were deposited than usually exists. Here an old sandstone and shale cliff, about 30 feet in height, has been enveloped by the traps, and subsequently disclosed by partial removal of their beds at a turning in the stream. The jurassic rocks are somewhat altered by contact with the trap, and a bed of white sandstone has a glistening fracture, like that already described at page 193.*

The Charwar range may be said to terminate to the eastward of this place, but the same anticlinal, or else one parallel to it, continues to the westward in the stratified traps of the Chitrana Hills.

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* In one or two places in this neighbourhood small portions of a band of "granular and compact" sandstone rock, resembling quartzite, were noticed by Mr. Fedden in the trap as though inter-stratified between two vesicular flows, with vertical tubes filled by zeolites and green-earth. The sandstone is described as altered and passing in one place laterally into a brown, decomposed amygdaloid, with small columnar structure.

The fact of this sandstone being inter-bedded is not so clear as in another case to be hereafter mentioned. At the place above described the white sandstone, said to be identical in character, was clearly of jurassic age, small portions jutting out from the old cliff having been enclosed by trap afterwards partially removed.

SECTION 8.—THE COUNTRY NORTH-WEST OF BHOOJ AND FURTHER WEST, INCLUDING THE JOORIA, WURRAR, AND VICHIA HILLS.

The steep escarpment which rises gradually from the low country west of Bhooj and edged by rugged cliffs overlooks the valley of the Kara river north-north-west of the city, is formed of a series of ferruginous, red and purple sandstones, alternating many times with grey shales in which plant fragments may be found and numerous curving narrow worm (?) tracks with a central line, on the surfaces of flaggy beds. All are overlaid by strong, white and red sandstones forming the edge of the escarpment. Near where the road from Bhooj to Dhosa crosses these hills, a spur formed of the more shaly beds below stretches out northward, and the escarpment turns sharply to the south of west, edging the valley to the south of Wurrar Hill, and is crossed by a long dyke of dark-grey trap, checked and crossed by another close to the village of Dhosa. Small veins of the red variety of trap accompany these dykes near the village.

Dhosa road.

In this neighbourhood purple craggy sandstones, with few shale beds, overspread the country, harder bands forming such abrupt rectangular hills as that called 'Palkiari', supposed to resemble a palanquin in shape. Some reddish and pale purple beds have red hard nodules, and certain white shaly bands with ferruginous partings, south of Wurrar and east of Dhosa, indicate that the rocks around the village underlie the thick shale zone which forms the heap-shaped hills in the latter direction and probably caused the precipitous forms of the scarp to the south and also that of the massive flat-topped hill of Wurrar.

In the open valley between Dhosa and the Jooria Hills, nearly horizontal olive and brownish grits and shales contain some of the first indications of the more highly

North of Dhosa.

fossiliferous marine beds in descending order, the following varieties being met with:—*Ostrea Marshii, Terebratula*, a *Pleurotomaria, Trigonia*, and undeterminable fragments of planulate *Ammonites*, besides some bivalves, *Pholadomya granosa*, and others.

To the north-east a low tract of rocky ground intervenes between this and the sandy alluvial plain of Soomraisir, in which two peaked hills close together are conspicuous.

Peaks to north-east.

These hills are traversed by one trap dyke at least and present a complex assemblage of silicious stone, like 'fault rock,' and of the soft infra-trappean grit. The relations are obscure, but it is probable that a line of fault occurs here. To the west of these hills, a long dyke of dark trap crosses the outworks of the Jooria Hills, and some smaller intrusions occur at a greater distance to the east, while an isolated rounded hill of trap rises in the low ground to the north.

Tertiary beds.

In this direction, just where the rocky ground meets the alluvial plain, the lower jurassic sandstones, hitherto nearly horizontal, become much disturbed, dipping northwards at various high angles or being nearly vertical, and a narrow band of tertiary beds partaking of their high dip intervenes between them and the alluvial plain. They are ragged, shaly, gypseous and yellow, more compact mudstones, bands which are crowded with *Turritella angulata* (?), *Echinoid* spines, and other fossils, such as *Ostrea multicosta*, Desh., *Pecten Favri*, d'Arch., *Scala sub-semilamella, Cerithium Hookeri, Arca hybrida*, &c. Another similar tertiary band similarly situated occurs south of the village of Jooria further to the west. The arrangement of these tertiary beds or their relation to the underlying jurassics is not clear, the great bulk of the upper jurassic group, usually between them and the beds with which they are associated, being absent as well as all the stratified traps. These great groups may have thinned out or never

have been deposited here, but it seems more likely that they are brought in by a great and possibly very complex line of faulting passing along the margin of the Runn from the eastern end of the Lodye and Joorun range the whole way to Lukput.

South and south-west of Jooria.

The hills south and south-west of Jooria are formed by one of the east and west arches on the anticlinal line which traverses the whole northern side of this part of Kutch. Conforming to the decline of the axis or spring of the arch, the beds fold round each end of the hills, being as it were pressed inwards just to the south of Joorun; the structure of the hills, but for this feature, much resembling that of the western portion of the Lodye and Joorun range lying to the south of east. The rocks are, however, somewhat different, calcareous beds being much more frequent here.

Plant beds.

The uppermost of the highly fossiliferous series met with north of Dhosa, after curving round the eastern extension of the hills and appearing in the low ground there, is again met with on the northern flanks of these hills passing beneath some purple and red sandstones highly contorted and letting in, south of Jooria village, close to the tertiary band a small basin of white sandy beds, having greatly the appearance of the upper group and containing the remains of fern-like plants, ramifying through the rock in such a manner that only imperfect portions of their forms are exposed by fracture. (These fossils present a striking resemblance to some found in the upper jura rocks near Nunnao hill, ante p. 197.)

Associated with these plant-bearing rocks in a very indefinite way, and forming a narrow band along the base of the few tertiary beds seen, are some of the red ferruginous and white earthy rocks, characteristic of the subnummulitic group, the mode of their occurrence being

probably obscured by dislocation as well as contortion of the beds in this locality.

Shales and limestones.

The main portion of the Jooria Hills is formed of grey shales and hard, pale-lavender grits or flags, with numerous beds of silicious and earthy, compact, pale-grey or dun-colored limestone. At some depth in these, and forming the higher portion of the hills, are several beds of golden oolite, which takes its brilliant metallic color from the calcareous grains being thinly coated with an oxide of iron. Many of the beds are fossiliferous,—to a slighter extent, however, than the overlying zone, surrounding and forming outer portions of the hills,—the fossils being of the usual kinds found in the lower part of the formation.

Thickness.

Taking the average angles of dip and the distance from the central portions of the quaquaversal arrangement of the rocks, the thickness of the beds forming these hills is estimated at 2,000 feet, to which must be added largely for the great series of beds coming in to the south forming Wurrar Hill, and extending with southerly low dips the whole way to the fault at the northern foot of the Charwar range.

The thickness of the whole jurassic series from the Jooria Hills southward to the Charwar and Katrol fault, is probably quite as great as that to the east of Bhooj; for though the rocks of these hills have not so large a calculated depth as that of the lower rocks near Lodye, the space occupied by the transition and upper beds is much broader. The extent of ground where the rocks undulate nearly horizontally makes it difficult to estimate closely their vertical depth, and the impossibility of ascertaining the amount of displacement caused by faults adds much to the uncertainty of the results.

Taking everything into consideration, the total thickness may be taken at from five to six thousand feet.

Wurrar Hill.

Wurrar, the commanding tabular hill south of the mountains just mentioned, rises with precipitous sides entirely isolated from the surrounding elevations. It is covered by a thick capping of black basalt, parts of which show columns of large size (quite equalling those of the Giant's causeway in Ireland), horizontally arranged, other portions presenting the usual varieties of texture. Its arrangement as a horizontal cap, beneath which sandstones are seen on all sides, would favor the supposition of its occurrence as a flow, but it is impossible to say that it did not issue directly from beneath, particularly as several trap dykes of large size occur round the hill. The thickness is unequal, but its maximum may be stated at 200 feet.

Beneath this are 690 feet of the pale-purple, flaggy, thick yellow and white sandstones and shales of the upper jurassic group, and many others below, which have been taken to represent the upper portion of the lower or transition beds. It is possible that a north-east fault coincides with the long dyke, having that direction at the east side of the hill, for the fossiliferous beds north of Dhosa were not found in the valley north of Wurrar.

Vichia Hill.

The conical peak of Vichia and some adjacent hills to the west-south-west are formed mainly of coarse sandstones undulating nearly horizontally, but the summits are occupied by intrusive trap, columnar on the former hill, in the neighbourhood of which are some smaller intrusions.

From this hill a ruggedly indented escarpment runs to the north-west, the stronger sandstones of which have a low south-westerly dip, and the valley between this and the widely curving beds of the western spurs of the Jooria Hills is occupied by alternating shales and sandstones forming strangely broken ground.

Budlee.

Westward of Vichia, in the more open ground about Budlee, numerous small hills are either traversed by trap dykes or formed of intrusive trap and white columnar sandstone.* The remainder of this country is occupied by the lower beds of the upper group, generally undulating at low angles and sometimes traversed by faults, which but slightly affect the general horizontality of the rocks, although sometimes accompanied by sharp local contortion.

Trap intrusion.

North-west of the ground just now described the country is crossed by a great intrusion of coarsely crystalline dolerite, rendered magnetic by titaniferous iron; traversing both the upper and lower jurassic groups. Its felspar sometimes crystallizes separately, giving it a syenitic appearance. Ramifying in an irregular manner, it crosses the stratification of the adjacent rocks through most of its course, but at its south-western end seems to die out between the beds there crossed by an east-north-east fault. It forms a hilly range, sometimes standing by itself, sometimes flanked by portions of the containing rocks, but always conspicuous as a ridge, with summits occasionally reaching a height of 400 feet or rather more.

The hill of Darmia between this and Dhenodur is covered by intrusive trap, and a branching dyke occurs near it on the north-west.

The rocks of this part of the country, colored as lower jurassic, partake more of the character of the transition or middle portion of the group, a long depression of the Jooria anticlinal axis here allowing the upper beds and those immediately below them to extend across nearly the whole country to the borders of the Runn.

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* In some of these hills, particularly those near Budlee, the sandstones appear to have been altered to an extreme extent, being partially blended with the traps, in a manner very similar to that of the re-melted block of syenitic granite enclosed in the traps at Mundlaisir in the Nerbudda valley.—*See* Mem. Geol. Surv., India, VI. p. 291.

Vitonia peak.

Vitonia Hill is an isolated peak, some 350 feet in height, near the south-western extremity of the large intrusion abovementioned. It is formed of intrusive, compact and sub-crystalline, dark, columnar basalt, which strongly affects the magnetic needle, crossed obliquely by a large irregular mass of soft trap breccia, with a sub-stratified appearance inclined at 15° to east-by-north. This is very friable and much decomposed, its soft débris slipping down the steep hill sides, but it contains cores or lumps of harder trap.

Some other intrusions of dark-grey trap occur in the vicinity, and one dyke of the purple kind intersects strong white and thinner red sandstones, coinciding with a line of reef or silicious fault rock eastward of Vitonia Hill.

Plains.

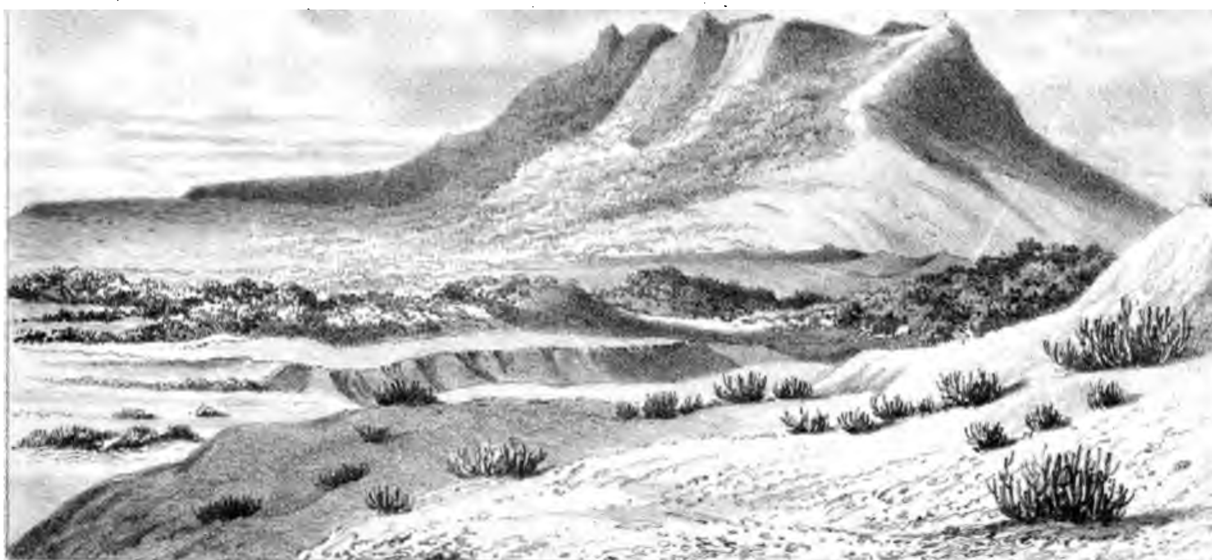
The plains of the neighbouring country are thickly covered by sand, the smaller hills being generally trappean intrusions.

Escarpment.

South-west of Vitonia a broad promontory-like escarpment of the upper jurassic rocks leaves the trap boundary, with which it usually coincides, and projects north-eastward into the plains. This escarpment was probably once covered entirely by the traps, considerable outliers of which still remain capping the hills of Lakria, Aklia, and some others in their vicinity, while hilly ground to the southward is entirely covered by their thick flows of the usual character, alternating with some dark-colored powdery varieties very similar to the soft band which crosses Vitonia Hill.

Powdery traps.

If these were not originally deposited as volcanic ash, they seem to have suffered from unusually intense decomposition. The general dip of the traps here is to the south-by-west, and the ground is crossed by a small, but distinct scarp along the outcrop of some harder beds.



B. Wynne. DHENODUR HILL FROM THE N. W. J. Schaumburg Lith:

Spur of trap resting on jurassics.

Northwards, a spur which leaves the trap escarpment near Vahar hill, extending to the village of Nukutrana, has all its summits capped by massive flows of trap. Two more outliers occur to the south of it, and some small hills not far from the above village are formed of intrusive trap.

Outliers.

Another group of trap outliers, the most northern of which may be in part intrusive, lies to the north-west of this, two of them capping the summits of Suri and Pal Pakra hills, portions of a chain formed of the upper series, which crosses the country from near Muttul towards the Runn and terminates at Jogee Arul. The trap of these outliers is, as usual, amygdaloidal and basaltic.

The outer portions of the trap escarpment in this part of the country are bold, and the white sandstones of the upper group frequently appear at considerable elevations upon their steep sides, cropping out from under and contrasting strongly with the dark trap.

Dhenodur.

On the line of depression which allows the upper jurassic beds to stretch across to the north side of the district is situated Dhenodur hill (Pl. IV), the fabulous volcano of Kutch. It is one of the most prominent hills in the province, rising to a height of 1,073 feet above the low ground near the Runn (or causing an aneroid barometric depression of 1·2 inches). The hill is mainly composed of the coarse and fine white sandstones of the upper jura group, resting upon the transition portion of the lower beds, and covered by a capping of basaltic trap, 180 feet thick. A large intrusion crosses the northern foot of the hill bending to the north-west. This may have been the source from which the overlying mass issued, or the latter may have found a vent through what is now the interior of the hill, the steep isolated character of which is manifestly due to denudation.

The northern declivity, as Colonel Grant describes, is covered by impenetrable babul jungle and traversed by a deep ravine, no uncommon occurrence in ground formed of trap like this, which seems to descend the hill side further on the north than elsewhere.*

To the south its base is thickly covered by calcareous, sub-recent, tufaceous concrete, and about half way up the hill the fine white sandstones contain *Palæozamiæ* of the kind most frequently met with.

Eastwards of Dhenodur, where the broken hilly ground formed of the lower jurassic or transition beds adjoins the alluvial plain extending westwards from Soomraisir, one or two small exposures of tertiary, fine-grained, yellowish, shaly grits were observed to contain a few gastropods and bivalve shells in bad preservation—*Ostrea* and *Pecten.*

The ground being low, the relations of the two formations are obscure, but it is probable that the junction is effected by means of a fault.

* The upper part of this ravine being somewhat more open is perhaps the *crater* alluded to by Colonel Grant in his paper on Kutch. The breccia he speaks of is probably the subrecent concrete.

SECTION 9.—COUNTRY WEST OF DHENODUR, INCLUDING THAT NEAR NURRHA, MALKA, AND THE HATHRIA ESCARPMENT.

North-west of Dhenodur.

From Dhenodur in a north-westerly direction the ground is greatly broken, consisting of alternations of flaggy, shaly and sandstone beds, occasionally traversed by trap dykes, the shales often forming mounds strewed over by the remains of an overlying flaggy band, and the harder beds cropping out as usual; the whole undulating horizontally rather than assuming a general dip.

Plant fragments, Jogee Arul.

Near Jogee Arul, an escarpment in the upper portion of these transition beds commences to show itself, just above which are some blue shales associated with strong, white, red, saline and blue sandstone, weathering brown. In the shale, after an hour's search, a few leaflets of plants, showing some of the venation, were found indicating an approach to the upper plant-bearing beds, such as were met with on Dhenodur hill. The escarpment is but slightly marked for some distance to the north-west, but further on shows more strongly south of the Keera hill, and extends as a bold and lofty demarcation for many miles between the internal sandy plain to the south and much lower ground to the north, formed almost entirely of shales, with small ferruginous nodules which thickly cover the surface.

Escarpment.

Outlier of the stratified traps, Oogulree.

A large outlier of the stratified traps occurs in this open plain between the villages of Koombree and Oogulree, in one portion of which a few horizontal beds of ferruginous and shaly sandstone had strongly the appearance of being interstratified between one of its soft, decomposed lower flows and more compact basaltic trap above.

Some 10 feet of the sandstone was visible in vertical section, and although one ferruginous bed appeared quite the same as many in the jurassic groups, the whole may very possibly belong to the infra-trappean grits.

Marine shells in upper jura.

Out in the plain, about a mile and a half to the north of Oogulree, where the ground is rather broken, horizontal, flaggy, rusty-red and white sandstones, with thin crisp shaly layers, of the upper series were found after long search to contain a few casts of small undeterminable bivalved shells and a few plant fragments and annelid tracks. The beds resemble those of Bhoojia hill close to Bhooj; and while they might occur in any part of the upper group, so far as petrological aspect is concerned, an open roll may here bring up some of the underlying transition beds; nothing was, however, seen to prove that this takes place. The occurrence of marine forms in the upper beds is very rare, and the place was being searched for *Zamiæ* when they were found here.

Plant-fragments near Amora.

In other parts of the plain the rocks present the usual appearance of the upper beds, but *Palæozamiæ* were only found in a few thin shaly bands near the village of Amora, at a distance to the northwards. Between this and Gudjeensir the thick shaly band which forms the fine escarpment traversing the country was carefully searched for plant-remains without success, a few *Belemnites* being the only fossils found.

Vicinity of the Keera and Charee.

The country in the vicinity of the Keera and Charee is hilly, one of the small elevations west of the latter village having an oblong shape, like another north of Bhooj, and being also called Palkiari. Near this hill and the village, and in the country to the west, are some strong compact amygdaloidal and concretionary basaltic dykes traversing hard, flaggy, light-colored and red sandstones and gray shales, either horizontal or undulating slightly. These

shales also were searched for *Zamiæ* with as little success as usual in the lower part of the formation, small casts of bivalve shells only being found.

The Keera hill.

The Keera hill is an intrusive peak of dense, fine-grained, sub-crystalline basalt, 380 feet in height, irregularly intruded among shales and red sandstones, the latter being rare here. It is extremely steep and difficult to ascend in consequence of the looseness of the shingle barely resting on its sides. Immediately to the south of it an oval quaquaversal arrangement of the lower beds occupies some hilly ground under two miles in length along the axis, and, as usual, the highest inclinations are those to the north.

The rocks are penetrated in various directions by intrusions of amygdaloid and basalt, some of which, having forced a passage between the beds for short distances, follow the lines of their outcrop.

The following succession was observed in descending order :—

6.—Coarse sandstones weathering brown.

5. { Thinner, smoother, and more flaggy beds, with black shales and occasional strong beds.

4.—Very strong, smooth, light-colored, yellowish sandstone, in places oolitic.

3.—Thick band of shales.

2. { Calcareous sandstone, shaly and muddy calcareous beds, with bands of golden oolite.

1.—Light yellowish sandstone.

Golden oolite.

The calcareous zone which resembles that of the Jooria hills contains strong bands of the golden oolite found there also, some parts presenting a greater development of the oolitic structure than others, though bands of it occur 80 feet in thickness. It sometimes contains fossils as do nearly all the beds of the locality, but, generally speaking, underlies the most fossiliferous bands. Some of the shale contains *Ammonites* in great numbers, which weathering out lie scattered over the surface; and from a hard, calcareous, blotchy bed forming part of the southern side of the dome one

specimen was with difficulty obtained, in a fragmentary state, which had originally a diameter of more than 2 feet (*Lytoceras rex*, Waagen, Mss.) Among the fossils found here are—

Phylloceras disputabile.	*Pholadomya inornata.*
Lytoceras Adeloides.	*Astarte pisiformis.*
Oppelia subcostaria.	*Trigonia costata.*
Harpoceras ignobile.	*T.* ... *interlævigata.*
H. ... *Hecticum.*	*Cucullea virgata.*
Stephanoceras macrocephalum.	*Nucula cuneiformis.*
S. ... *tumidum.*	*N.* ... *hemistriata.*
S. ... *Grantianum.*	*Ctenostreon pectiniforme.*
S. ... *Opis.*	*Ostrea Marshii* and *many other species of Pelecypods* and *Brachiopods.*
Perisphinctes arthriticus.	
P. ... *calvus.*	
P. ... *curvicosta.*	

Manjal hills.

The Manjal hills south of Nurrha present another example of oval arrangement of the beds, caused by vertical distortion and flexion on the anticlinal axis of this coast range.

The locality is one of great disturbance, and the quaquaversal contortion, like those of the three cases already mentioned, has its axis lying east and west, so as to cross obliquely here the main north-westerly axis of the larger anticlinal, denuded portions of which form the chief hills in this part of the province. The core or centre of the hills is formed by a great intrusion of coarsely crystalline, doleritic trap, with pinkish and light-colored felspar, sometimes separately crystallized so as to give the rock when weathered a coarse, syenitic-looking surface; its general structure and appearance being the same as that of the long Arrara intrusion south-east of Dhenodur. In the centre of this trap, great masses of the calcareous lower jurassic beds are enclosed, so highly altered at their junction in some spots, that although one hand may be placed on the trap and the other on part of the enclosed mass, no definite line of demarcation can be seen. In one section where this intense alteration takes place on the north side of the hills,

and the shaly rocks at the junction assume the color and splintery fracture of decomposed trap, lines were observed in the adjoining solid basaltic rock continuing, as it were, those of the stratification of the jurassic shales and harder bands, as if the whole of the latter had been melted *in situ.*

The appearance of bedding in the solid crystalline trap could only be traced for about 50 feet horizontally, and was not observed where this trap underlies a capping of strong sandstone on the east side of the same ravine in which the above section occurred.

The beds which fold round and dip in all directions from this intrusion consist of impure grey and dun-colored limestone, strong blue and greenish-olive calcareous grits and cherty bands, with oolitic blotches (resembling somewhat the golden oolite south of the Keera). Besides these there are many bands of dark-gray and rusty shale overlaid by coarse, pale red sandstone alternating with gravelly layers and gray sandy shales and flags.

On the outer slopes of the hills, coarser and redder sandy beds, still with shale bands, and a few calcareous shelly layers prevail, and are found to contain numbers of the usual fossils of the lower group, some few of which occur in nearly all the beds of this locality. They also contain some *Ammonites*, one of which is a *Stephanoceras* allied to *Macrocephalus*, and another is *Harpoceras serrigerum.* Associated with these outer beds are trap dykes and intrusions between the planes of stratification.

Zamiæ in marine beds at Nurrha.

A considerable stream finds its way to the Runn between the Manjal hills and the village of Nurrha, through low ground to the north, said to have been depressed during the earthquake of 1819. On the north bank of this stream, where it has cut a cliff close to the village, an oblique section of the rocks consisting of thick dark shales and flags between strong sandstones is exposed.

They dip to the north by west at low angles up to 20°, evidently the continuation of the similar northerly dip on this side of the Manjal hills, and at one spot the dark shales, showing a thickness of 25 feet, have thin layers containing some poor but recognizable impressions of *Palæozamiæ* and *Pecopteris* or *Alethopteris.*

Close to this place a two-foot band of concretionary trap, somewhat shaly above and below, lies between the flaggy shales and some sandstones below them; notwithstanding its position, it is probably part of a local intrusion.

Some of the strong sandstones overlying the shales close to the west side of the village contain obscure casts of large bivalve shells, and one *Belemnite,* though badly preserved, was detected in them. Thus, within a short distance, shales containing terrestrial plants were found interstratified between the marine beds of the Manjal hills and a newer band also containing marine fossils. A few hundred yards to the west-south-west along the strike, this section is crossed by a strong intrusion of basaltic trap, sending out dykes in several directions from Jogibit hill between and across the beds, and apparently linking the trap of the Manjal hills with the larger intrusion to the westward. It is unlikely that the fracture occupied by the trap here was not accompanied by dislocation to some amount, but this may not have been very great.

Jogibit.

Just to the westward of the trap in thin, flaggy, and shaly pink and variegated beds, dipping slightly to the northwards, like those containing the *Zamiæ*, are small *Nuculæ*, *Pecten*-like shells, and *Trigoniæ*, which, if displacement did not occur, would occupy a place very near the horizon of the *Zamiæ* layers.

These marine beds underlie olive, gray, greenish, purple, sandy and flaggy beds, with some black altered shales on the small hill called Jogibit.

Northwards from this the irregularly branching eastern termination of the great intrusion of West Kutch runs among the hills in the neighbourhood of that called Thassa, sometimes forming a considerable portion of their bulk and supporting caps of whitened altered sandstone, or occupying hollows between them.

Eastern termination of the great intrusion of West Kutch.

To the north-west of Nurrha, the eastern slopes of these hills are formed of coarse, gravelly, and fine light-coloured sandstones, flags, and dark-gray shales, dipping to the south-east at 15° and 20°, so as to form a synclinal curve with the beds near the village and in the river. They were not observed to have any fossils; but crossing the northern spurs of these hills, a small patch of dark-colored shales, with flaggy bands strongly ripple-marked, being almost surrounded by the intrusive traps, contained *Palæozamia* again in better preservation than those found at Nurrha.

From the position of these shales it is not possible to fix their horizon more nearly than by saying that they appear to belong to the adjacent lower jurassic beds.

***Zamia* bearing shales north-west of Nurrha.**

The trap of the vicinity is coarsely crystalline, and the lower jurassic beds present several varieties of gray silicious grits, weathering of a bluish color, red and greenish, sandy and flaggy beds, brown, pink and whitish sandstones, with some dark shales having ferruginous nodules.

In order to illustrate better the positions of the *Zamia* bearing beds abovementioned, the following sketch section, taken about north-west through both localities, is subjoined.

Fig. 17.—Sketch section across the marine and interstratified plant beds of Nurrha.

? "Wall on the Runn."

On the margin of the Runn, northward of some hills here, largely composed of the intrusive trap, a single strong sandstone bed, forming part of a horse-shoe-shaped synclinal contortion, projects on the flat ground and is supposed to be one of Colonel Grant's "walls on the Runn."

Tuksar.

Between the Manjal hills and the fine escarpment of Chapar there is a strong east and west feebly porphyritic basaltic dyke, which at a place called Tuksar was said to have been the site of ancient mines where many metalloids were found. The place on being visited was not found to show traces either of mines or metalliferous minerals.

Central plain south of the Chapar and Kaniri escarpment.

The central plain between the gentle south and south-western slopes of the long Chapar and Kaniri escarpment and that of the stratified traps, is often sandy, but in places the rocks appear undulating, at its surface. Silicious, fault-rock-like reefs prevail as usual, running in various directions. An end view of one of these, mentioned by Colonel Grant, at the village of Guranee, and an oblique view of another strongly marked, south of Malka, are annexed. (Plate V.)

Quartz reefs or ramps at Guranee and Malka, &c.

The latter, as is often the case with these indurated lines, presents a false appearance of stratification outcrop, the true bedding in its vicinity being either nearly horizontal or dipping gently south by west, nearly in the direction of its strike. Other strong reefs occur in the neighbourhoods of Koombree and Naithra.

The rocks of the plain are of the usual upper jurassic varieties, such as are mentioned in the section beneath.

Marine fossils near Guranee.

At a little distance to the west-south-west from the village of Guranee, a recess in the outline of the trap area is occupied by the upper jura beds, crossed

CRAG ON QUARTZ REEF AT GURANEE.

QUARTZ REEF SOUTH OF MALKA.

by several strong ramps. In the part of this nearest to the village, the rocks are greatly disturbed, dipping to the north at high angles, and a bed of coarse, ferruginous, quartzose grit, about 3 feet thick, contains obscure casts of large bivalves, one of which resembled *Trigonia Smeeii*, both rock and shells much resembling the beds and some of the contained fossils which overlie the *Zamia* bearing shales at Nurrha. Although the place has a faulted appearance and the high dip is very local, no distinct throw could be made out. The rocks in the vicinity have the usual aspect of the upper beds, and the balance of evidence is in favor of this being another instance in which marine remains occur, though rarely, in the otherwise plant-bearing strata of the upper group.

The following is a carefully-measured north and south section across the edges of the more highly-inclined beds, the horizontal thicknesses deduced in the usual manner :—

Descending order.

		Ft.	In.
11.—Soft white sandstone	dip N. 45° ...	35	0
10.—Red and white, variegated flaggy shale	„ „ ...	28	0
9.—Nearly blank, some white sandstone here and there...	...	10	0
8.—Variegated, purple and white, blotched and purple, ferruginous beds, obliquely laminated	„ „ ...	35	0
7.—White sandstone with ferruginous layers ...	„ N. 50° ...	91	6
6.—Sandy ferruginous purple beds	„ „ ...	15	0
5.—White sandstone, very coarse	„ „ ...	268	0
4.—Coarse, purple and yellow sandstone, with ferruginous layers	„ „ ...	101	6
3.—Coarse reddish and yellow sandstone	„ „ ...	95	6
2.—Purple, ferruginous sandstones, with quartz grains, in which a band containing obscure casts of marine shells occurs	„ „ ...	15	0
1.—Flaggy, greenish white sandy beds	„ „ to vertical	100	0
		794	6

(A vertical silicious east and west ramp of 3 feet, one foot very silicious).

Stratified traps to the west of Mhurr.

The irregular outcrop boundary of the stratified traps along the south-western side of the central plain here coincides generally with a strongly marked escarpment formed of the upper jurassic rocks, overlaid by the abruptly

terminating edges of the trap flows. The latter are of the usual dark, basaltic, and softer amygdaloidal kinds. Their dip undulates at low angles, being generally to the south and south-west, and their connexion with the remainder of the trap area is interrupted to the south near Naithra, and again in the immediate neighbourhood of Mhurr, by the intervention for short distances of other rocks.

Intertrappean near Lukmeepur.

At the southern side of this isolated portion of the trap area is a narrow recess from which they have been denuded, exposing the jurassic sandstones as highly silicious craggy hills, projecting above the surrounding trap flows. Near the western edge of this, not far from the village of Lukmeepur, some cherty blocks and shaly fragments of intertrappean beds, containing *Physa Prinsepii*, were found scattered over the surface of a small ploughed field, the soil of which also contained many of these fossils. The band could not be found *in situ*, but there was no doubt of its occurrence near the spot. These fossils afford an additional proof of the identity between these traps and the accumulations of the Deccan. A little *Bulimus* or *Lymnea* and two or three pear-shaped fruit-like bodies, ribbed outside, but without internal structure, were found at the same place, as well as a few woody plant-fragments. A peculiar crystalline trap, with separate felspar and augite crystals, which may be a dyke in the other traps, occurs in a stream close by the locality.

Sandstone bed in traps near Malka, &c.

The northern extension of this portion of the traps in the neighbourhood of Malka presents a strong scarp towards the plain, the base, as usual, formed of the jurassic rocks. Among the lowest trap flows here a 30-foot bed of soft red and mottled red and white sandstone, with distinct quartz grains, is clearly interstratified and may be traced for a considerable distance.* It is well seen in the left bank of a stream about a mile

* This sandstone, clearly interstratified with the traps, is an unusual feature in Kutch, but may find a parallel in those north of the Nerbudda, described in Mr. Blanford's Report, Vol. VI, part 3, page 165.

and a half to the south of Burra Malka, resting upon a thick bed of amygdaloidal concretionary trap, with an irregular upper surface. The junction with the next flows above does not appear in the sketch, but they occur of the usual basaltic character at a short distance in such a position as to overlie the thick sandstone bed.

Further to the south-east in the steep northern face of the spur, which extends nearly to Guranee, this bed was again met with, though apparently nearer to the local base of the traps, where the following succession was noticed :—

Descending order.

		ft.	in.	
STRATIFIED TRAPS	7.—Stratified traps, amygdaloidal and basaltic.			
	6.—Red, soft, boley sandstone	30	0	
	5.—Concretionary trap	20	0	
	4.—Layer of purple and white amygdaloidal ? volcanic mud	0	6	
LOCAL UPPER JURA.	3.—Thin purple, altered, silicious, jaspery parting.			
	2.—Strong white and red sandstones	5	0	
	1.—Similar sandstones	40	0	&c.

The alteration caused by the lowest trap No. 5 is very slight, and only traceable for about 8 inches downwards.

SECTION 10.—NORTH-WESTERN KUTCH, INCLUDING GAIRA, KOOND, AND MHURR DISTRICTS.

Great intrusion of Western Kutch.

The large intrusion which terminates near Nurrha is traceable westward for about 16 miles, forming either a narrow, but distinct ridge near other hilly ground, or expanding into clusters of small hills, sometimes of very complicated structure, the trap having been intruded so as to overlie or support portions of the sandstones, or to penetrate the latter in an intricate tangle. One portion of the intrusion obliquely crosses the axis of the anticlinal, which affects the lower jurassic group, but its north-western extension irregularly coincides with the general strike of the strata south of the curve.

The trap throughout is mainly of the coarsely crystalline kind, described as occurring in the Manjal hills, and also in the Arrara intrusion south-east of Dhenodur. Some small outlying portions in its vicinity are less coarsely crystalline and sometimes columnar. From its amorphous character, hills and ridges formed of trap have massive forms, by which they may be distinguished even at a considerable distance, and the intrusion sometimes ascends the flanks of the lower jurassic hills, with a certain appearance of conformity here and there, as if the main fracture had run more or less along the planes of stratification.

West of the Manjal hills and near Akela hill.

Due west of the Manjal hills, near an isolated elevation called '*Akela*' (alone) or *Aklia*, a very thick (30 to 40 feet) band of light colored coarse sandstone comes out from beneath the base of the Chapar scarp and forms singularly craggy ground, the dips of the sandstone being in various directions. In a nullah here, some underlying greenish gray 'felted-looking' lumpy, nodular shales forming its bank are seen to

pass laterally into thin bedded, dark, flaggy shale having in many places a bright yellow efflorescence exuding from between the layers. This passage of a thin bedded into an apparently but slightly stratified deposit may illustrate the possibility of many such lateral changes which from the difficulty of tracing out separate beds have often been suspected to affect the jurassic rocks of Kutch. Light-colored and red sandstones with highly ferruginous layers, full of annelid tracks, prevail in this neighbourhood.

Country near Jumara, north of the large trap intrusion.

Northwards from this on the further side of the intrusive trap ridge, a valley is reached which opens on the Runn. Here near the intrusion, very strong, coarse white sandstone, of the aspect of the upper series, associated with greenish flaggy layers, and perhaps let down by a fault coinciding with the intrusion, overlies a strong band of black shales, in which were found some plant-fragments and a few casts of an extremely thin bivalve shell, evidently a species of *Corimya*, unfortunately not determinable; but the shale was so tender and the shell so thin that specimens were difficult to obtain. In some green flaggy layers narrow winding tracks, probably molluscan, were observed.

Some light gray sandstones in this strong shale band are full of brecciated shale fragments, and near the base of the zone are black, blue, and gray earthy sandstones, with rusty and coarse white beds. At one place in this zone a local unconformity, or what is more likely, oblique lamination on a large scale, interrupts the regular stratification of massive beds of dark sandstone, with shale partings and layers, the beds in a river cliff, 30 feet high, appearing to thin out against the ends of others of quite similar kind.

Fossiliferous and calcareous zone.

Further north, beyond the village of Jumara, a dome-shaped arrangement of the lower beds on some slightly rising ground brings to the surface the fossiliferous zone

and underlying calcareous rocks on a smaller scale, but in very nearly the same order observed at Manjal hill, south of the Keera and other places already described; the golden oolitic beds were not, however, observed here.

Trap, &c.

A band of amygdaloidal trap had the appearance of being intruded between the beds of the reddish, nodular, shaly zone, containing *Belemnites*, *Terebratulæ*, *Ammonites macrocephalus*, *Avicula*, *Thracia*, and other fossils of the same character as at Keera on the same horizon.

Limestone with fossils.

The underlying gray, impure limestone and shales contain comparatively few, but some very interesting fossils. Some *Ammonite* fragments, *A. sub-contractus*, well known in the European Bath group, a small species of an *Elymus*, and a great number of *Terebratulæ*, *Rhynchonellæ*, and the thorny, flattened, spines of *Rhabdocidaris* were observed.

Jarra cliffs.

From this place a fine view is obtained of the Jarra cliffs (famous as being an old battle-field on which the Kutchis met with great disasters according to their own accounts). The shaly and sandstone beds of which they are composed are seen to dip at low angles to the south-west, while some smaller hills nearer to the Runn equally plainly show the opposite inclination on the other side of the anticlinal axis.

Jarra.

In the neighbourhood of the deserted village of Jarra, a thick zone of dark-blue and gypseous shales,· with numerous small red nodules, weathering out and thickly strewed over the ground, occupies the interior of the anticlinal curve and rises in the faces of the cliffs to heights of more than 200 feet. These shales contain plant-fragments and small casts of shells. Hard craggy sandstones also occur in the low ground near the axis, and the shales continue for some miles to the westward towards Moondan, near which place

they disappear beneath the harder beds, forming the hills on each side of the curve, here extending over a depression of the axis with westerly and north-westerly dips.

Cliffs south of Jarra.

Ascending the cliffs through a gorge south of Jarra, strong light coloured sandstones and grayish calcareous grits are found to overlie the shales; and some thinner beds, forming the peak of Soorka, are seen to dip to the south-west at 10°. The contrast between the shales and stronger overlying beds is well seen in the cliff beneath the battle-field on the eastern side of this gorge. (Fig. 18.) In the gorge itself some very solid sub-recent calcareous conglomerate occurs, having been formed apparently by exfiltration from the calcareous beds in the neighbourhood.

Fig. 18.—Jarra cliffs: Western Kutch.

Near Hurroora.

Smaller developments of shale occur again at the head of the gorge with calcareous grits sheeting the gentle slopes of the plateau, above which, portions of the intrusive trap rise into hills in the neighbourhood of Hurroora.

Northward of this village there is some local disturbance of the rocks, and a black muddy band, dipping sharply to the south-west, contains *Ammonites*, *Belemnites*, a large *Cucullæa*, a small *Ostrea*, *Rhynchonella myriacantha*, and fossil wood. Horizontal black shales and sandstone at the village and near it are capped by hills of the intrusive trap, sometimes supporting small outliers of white altered sandstone, and on the road to Joonacha, a large *Trigonia*, like *T. Smeeii*, occurs in weathered sandstone beds overlying black shales. The intrusive trap occurs in force in this neighbourhood, and the black shales with *Ammonites*, *&c.*, were not observed anywhere else in the whole province.

Large ripple marks.

Near the last named village gigantic ripple marks on the surface of some close brownish sandstones, lying nearly horizontal, were at first sight taken for the drills of a field; they measured 4 feet from ridge to ridge, and exceeded in size anything of the kind seen elsewhere in Kutch.*

Plains near the Goti chain of hills.

Southward of this place is a broad sandy plain, in which horizontal rocks of upper jurassic aspect are occasionally seen, extending to a north and south chain of hills, which connects the trap escarpment near Malka with the fine hills of Gândara. This chain also exposes the white upper rocks, and another great plain covered by sand and broken by a few isolated sandstone hills extends westward to the margin of the stratified traps near Rora and Asooree.

Oomia.

Near what may be spoken of as the north-western termination of the great central plain, the hamlet of Oomia lies between the sandstone spurs from Gândara and the intrusive trap hills to the north. A solitary peaked crag of dark-brown massive silicious grit marks the site of the village, present-

* Another ripple mark of this kind, but less well exposed, occurs near the north-east bastion of the city wall of Bhooj, in red sandstone beds.

ing an abrupt scarp towards the trap hills. Cropping out from beneath this crag, and forming the low ground near, is a peculiar green earthy strong-bedded sandstone, full of earthy tubular casts. The bedding surfaces are studded with large specimens of *Trigonia* closely allied to, but specifically distinct from, *T. Smeeii* and a *Trigonia* almost identical with the south African *ventricosa* of Kraus. This fossiliferous band may represent that with large *Trigonia* and *Cucullea* near Hurroora on the other side of the great intrusion. Its horizon is difficult to fix on account of probable dislocation connected with the occurrence of the trap, and the association of the Oomia band with beds of upper or upper transition aspect differs as much as the nature of the rock does from that containing *T. Smeeii* in greater profusion, at the distant locality of Idderghur east of Chobaree in Wagur. Here at Oomia the band seems to occupy a position not far beneath the upper group, while in Wagur, beds both above and below those with *T. Smeeii* contain *Ammonites* and several other marine forms.

Zamia, north-west of Oomia.

In the low ground somewhat more than a mile to the north-west under some soft white sandstone are nearly horizontal olive sandstones and dark shales. In these beds large and small plant fragments and some obscure bivalve shells occur, while close by an imperfect *Zamia* impression on a piece of the shale was picked up, but none could be found *in situ*.

Gândara hills.

The fine hills of Suri-Gândara and Mal-Gândara raise their summits (the former to a height of 534 feet) above the low ground near Lakapoor. They are steep in all directions and faced by a bold cliff, south of that village, which turns at Mal-Gândara so as to overlook Oomia. The high cliff and most of the hills are formed of white and purple sandstones, conglomeratic beds and ferruginous shales. But the summit and some peaks near it are composed of basaltic and softer trap. No lines of flow or

stratification were observed, and the sides of the trappean portions are so shot over by spilled blocks that their intrusive character is equally concealed.

The open plain west of the Gândara hills is occupied by the upper jura sandstones, but these are sometimes quite hidden by their own superficial debris.

Lakapoor.

Between the base of the hills and the village of Lakapoor, a four-foot band of rather ashy-looking and more solid trap is intercalated with nearly horizontal light coloured sandstones and ferruginous grits, while intrusive traps in this part of the country have so frequently an interbedded appearance that this cannot be asserted to be contemporaneous.

Infra-trappean.

The great intrusion expands north-west of Lakapoor and becomes so complicated by passing between the jurassic beds and enclosing considerable portions of them that its general outline only has been attempted to be shown upon the map. It forms a narrow ridge near Lakapoor, on the north-east side of which are some peculiar soft mottled sandstone beds, of coarse grain, resembling the infra-trappean grits of Bhoojia hill and other places. They contain silicious masses obscurely like fossil trunks of large trees. Some gray sandy shale in these beds has the appearance of being recomposed from the detritus of trap, and the whole group with a very slight southerly inclination has a thickness of about 100 feet.

Lower jura fossils.

The jurassic sandstones of this country are generally very coarse, sometimes white, sometimes oolitic, and often conglomeratic, forming rough ground between the intrusion and the anticlinal to the north-east, from which they dip at angles of 10° to 25°. At one spot west by north from Soorka peak, the beds coming directly from thence contain a greenish, shaly, oolitic and sandy band, calcareous in places, and about 50 feet in thick-

ness, which is highly fossiliferous. Here *Rhynchonella myriacantha* is very numerous with large and small *Ammonites* of undetermined species, a very large *Pecten* 7 inches by 8, and a large shell resembling an *Astarte*, 5 inches wide; *Trigonia costata*, a *Terebratula*, *Belemnites*, &c., occur.

Below these are coarse purple sandstones with separate grains of white quartz, alternating with light gray or brownish flaggy beds, and shales which waste away to mud, the beds becoming more shaly and flaggy downwards until the shaly ground overlooked by Soorka and the Jarra cliffs is reached.

Moondan.

In the neighbourhood of Moondan, coarse and ferruginous sandstones, with some beds of slightly micaceous shale, form a small open valley and broken or hilly ground around it. The shaly beds as usual contain plant fragments, but other fossils are rare. On a rocky ridge running east and west, part of which forms the north side of this valley, similar coarse and some thinner bedded sandstones dip to the southward at 30°, the thicker brown bands being speckled with small white grains of quartz. A gorge which crosses this ridge north of Moondan exposes thick, soft, brownish sandstone, fretted into pillars and cavernous hollows, parts of which contain large strongly ribbed casts of thick bivalve shells matted together, often very imperfectly preserved and difficult to extract from the matrix.

Sandy shales 100 feet in thickness overlie these, and there is evidence of disturbance and faulting both north and south of the ridge.

Further west near Sairee, there is reason to believe that a fault passes along the base of the ridge in the low ground near the Runn, and a curvature of the beds along it allows the fossiliferous rocks of the lower beds to appear. They contain *Belemnites*, oysters, and a few *Ammonites*.

South-west of Moondan.

Southward of this place, and south-west of Moondan, curious partial patches and heaps of sand seem to have been collected on parts of the hilly ground by wind, and some solid dark concretionary basaltic and decomposed trap (the western extension of the great intrusion before mentioned) forms low hills.

On the north side of these, and dipping towards them, are about 30 feet of rugged rocks, externally somewhat like jurassic beds, overlaid by white silicious and coarse sandstones. These when broken into are found to have the decomposed or trap-impregnated appearance of the infra-trappean beds. They rest upon white granular quartzose sandstones, and all seem to be penetrated by the trap or entangled with it: some small trap hills being capped by white altered sandstone of a quartzite-like texture, underneath which is a peculiar silicious and ferruginous breccia made up of fragments of white sandstone and soft muddy trap.

Some thick, black and gray variegated shales, underlying strong yellow sandstones near this, are crossed by a dyke of columnar basalt, the columns being pentagonal, straight and curved, and 20 feet in length. The dyke has a width of 50 yards, and seems to be the termination of the large intrusion in this direction.

Stratified traps of Lickka and Uttra hills.

From this place westward the upper jura sandstones sweep in an open curve with a low southerly dip past Uttra to the base of some trap hills beyond, and are seen to form much of the northern escarpment edging this outlying mass of the stratified traps, extending from Lickka to Uttra hills, both included.

These traps are of the usual basaltic kinds, dipping with gentle inclinations to the south by west. The hills formed by them rise to heights of 360 feet above the lower ground in the vicinity, and they are separated by an open jurassic plain from their larger development to the south-west.

The isolation of this trap outlier has an important bearing upon the geology of the district. If it were caused by denudation previous to the deposition of the sub-nummulitic group, the latter must be everywhere unconformable to the underlying traps. This, however, is not borne out either by observations in detail or the general persistence with which that band occurs, always in such positions as to overlie the newest of the trappean flows.

An unconformity marking such an interval of time as would be required to remove by denudation some 200 feet or more of these traps from the country between Dharisieu and Lickka hills, might have been expected to leave many inequalities in the trap surface where this band of sub-nummulitic beds, often not more than a few feet in depth, would be completely concealed by the overlying lower tertiary deposits. On the other hand, it is plain that the trappean flows or beds of these localities once extended further towards each other than they do at present, and that so far denudation has removed them. The junction of these traps with the overlying group takes place in low ground, where the relations are much obscured and thinning out of the traps is difficult to determine, but notwithstanding this, it is probable from the general relations of the stratified trap to the succeeding group, that the Lickka hills outlier either existed originally as a separate accumulation or that such an inequality of the old jurassic surface existed as prevented the flows of this outlier from joining those to the south.

From the occurrence of the stratified traps again at Bheti hill to the west, it is probable that the Lickka flows extend in that direction beneath the newer rocks.

Termination of the jurassics near Goonaree.

In the neighbourhood of the small village of Goonaree, the last of the jurassic rocks of Kutch in this direction disappear among sundry complications. Their general aspect is that of the upper or transition portion of the group,

but they have peculiarities not elsewhere observed, and their arrangement is obscured by the occurrence of faults, which, owing to a general similarity of the beds, are difficult to trace, except where these are brought into highly disturbed contact with the nummulitic rocks.

In a stream-course south-west of the village and at a short distance from it, thick light-coloured sandstones and dark gray shales dip to the westward at angles up to 30°. These shales contain several faintly marked indefinite stars of many radiating lines, but whether of organic structure or not was undeterminable. One fragment of a *Zamia* was found in the shales, and not far from the spot the same beds more nearly horizontal contain a coaly layer, composed of thin bright seams in a carbonaceous shale 2 feet thick. The appearance of the rocks here much resembled that of the Trombow coal locality.

Further up the stream there is a sudden change in the dip of the sandstones and shales from south-west at very low angles to 40°, 55°, and 60° in the same direction, accompanied by a fracture along the strike of the more highly tilted beds bearing east 15° south. This high dip extends for a few yards across the strike of some beds differing from those in the neighbourhood, cut off to the east and west, and in fact surrounded by faults. The section of the group thus let in is as follows:—

Natural order.

	Ft.	In.
6.—Green ashy trappean beds	10	0
5.—Rotten green ash	4	0
4.—Ashy shales	12	0
3.—Decomposed green ash	1	6
2.—Ferruginous bed, red speckled with green (? ash) with sub-angular quartz grains, and fragments of wood	3	0
1.—Dark-green, friable, ashy looking rock with quartz grains. Entire thickness not seen.		

The only fossils found were the woody fragments, and something resembling part of a shell in the bed No. 6. The proper place of these

rocks is difficult to tell, seeing that the group as above is unknown elsewhere, but a similarity of one of the beds to a rock found further up in the series leads to the supposition that some of the higher jurassic beds have been let down here by complicated faulting. The fracture which cuts off these rocks to the west would seem also to have brought the coaly shales above noticed into juxtaposition with lower beds.

Reed or grass-like fossil plant.

In the strike of the faulted rocks of the above section, to the east, is a small hill of rugged ferruginous sandstone, underlaid by blackish brown shales. At the base of this hill a small vesicular ferruginous deposit with quartz grains, very obscurely related to any of the surrounding rocks, contains tubular and striated casts of a *Calamite*-like plant, very fragile, but in good preservation. They are quite the same as the fossils mentioned as occurring to the north of Kaira old fort.

Around the faulted patch the rocks dip at low angles again to the west and south-west, consisting generally of coarse sandstones, shales, and ferruginous beds, traversed by many 'ramps' and slips.

To the west at a little distance, a soft purple highly ferruginous bed, although associated with rocks of upper jurassic aspect, contains obscure casts of a small *Astarte*, an oyster, some *Trigoniæ*, like *T. gibbosa*, and another species very like *T. ventricosa*,* Kraus, from South Africa, the same as that occurring at Oomia. Some coarse beds here also contain fragments of fossil wood.

Escarpment near base of sub-nummulitics.

Still further west is a strong, but very rugged and broken escarpment formed of yellow sandstone, 50 feet thick, with a band of ferruginous bole associated with a thick

* One of the fossils found about two miles west-south-west of Goonaree, *Trigonia ventricosa*, Kraus, or very closely allied to it, according to Dr. Stoliczka, possesses interest, a similar form of *Trigonia* having been hitherto met with only in cretaceous beds in South India and in rocks which are said to be jurassic in South Africa. It occurs here with some other *Trigoniæ*, &c., in beds apparently conformable to the rest of the upper jurassic rocks of the locality.

shale band, having large concretionary masses of lavender ashy looking clay together with red earthy and splintery lateritic beds.

The yellow sandstone is speckled with paler yellow and crossed by red hæmatitic strings; its stratification oblique or false bedded to an extreme, and the colouring of the whole place most brilliant,—purple, red, and yellow. This is close to the junction of the sub-nummulitic group, and many or all of these highly coloured rocks may belong to them, but some strongly resemble the upper jurassic sandstones. All appear to dip at a low angle westward. Resting nearly horizontally on these beds is a thick lateritic block-breccia with concretionary structure weathering into fantastic forms. It has white brecciated earthy fragments in a red paste, and quite resembles a rock in the same position at Mhurr (to the south-south-east), except that it contains ferruginous instead of trap nodules. In continuation with this breccia the basal part of the sub-nummulitic group towards the south-east is formed of strong red clayey laterites associated with irregular lavender earthy beds, apparently just over or in its upper part, and underlying reddish brown shales containing quantities of gypsum.

The nummulitic group here extends to a width of two miles, but the ground is much obscured by sub-recent concrete and superficial accumulation consisting largely of jurassic debris.

Trap hill.

In this neighbourhood close to the laterite zone is a single steep hill of close porphyritic basaltic trap, about 100 feet in height, almost surrounded by a softer weathered or decomposed looking variety with enclosed lumps of basalt.

On its south-west side the softer trap is indescribably mixed with the sub-nummulitic rocks, a rubbly ferruginous concretionary trap ramifying among the white clays and vesicular ferruginous beds. The trap of this hill is believed to be at least in part intrusive, while the softer portion may or may not have been ejected here.

Near the base of the hill on its south-eastern side, some bright green ashy looking beds with red bands mottled green have greatly the appearance, but perhaps not quite the thickness, of the steeply dipping faulted beds of the section above given, p. 230. They are here nearly horizontal with a low inclination to the south-west, and, as in the other locality, contain scattered grains of quartz. They rest upon a very soft coarse greenish sandstone.

Ashy beds in the upper jurassic group.

Above these unusual beds is a compact speckled slightly calcareous buff grit, over which a gray compact calcareous band about a foot thick, occurring at the northern foot of Uttra hill, contains a layer or two crowded with broken shell fragments and small fragmentary *Belemnites*. The beds here dip to the south at about 5°, and are almost immediately overlaid by the lowest portion of the Lickka and Uttra traps, consisting of sandy looking concretionary ash, with low unsteady dips to the south and south by west.

Belemnites in upper jurassic beds.

The unconformity of these traps upon the jurassic beds is not appreciable on the spot, but seen from the small trap hill to the north-west becomes very apparent.

Just at the village of Goonaree and near it, strong light-coloured sandstones variegated with red, ferruginous bands and grayish flaggy shales form a small anticlinal to the westward, and are contorted along the fault which brings into junction with them the vertical white and yellowish marly nummulitic beds, showing as a narrow band along the margin of the Runn.

Fault bringing in the nummulitic beds.

A mass of basaltic trap occurs in this fault about a mile from Goonaree to the east-south-east.

To illustrate the structure of the country in the neighbourhood of Goonaree described, the following sketch section is subjoined:—

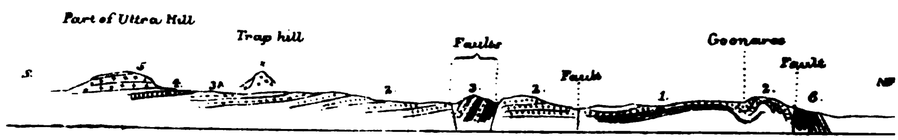


Fig. 19.—Sketch section near Goonaree.

1. Black coaly layer in shales with *Zamiæ*. 2. Upper jurassic sandstones, &c. 3. Ashy beds let in by faults. 3*a*. The same regularly interstratified. 4. Calcareous band with *Belemnites*, &c. 5. Stratified traps. 6. Nummulitic beds. X. Intrusive trap west of line of section.

West of Goonaree.

In the stream course, next to the westward of that which passes by Goonaree, strong light-coloured sandstones of the upper jurassic kind are seen, undulating nearly horizontally and at one place in unconformable junction with some obliquely laminated and flaggy beds, overlying a blackish and reddish damp, waxy-looking shale, banded with purplish white sand, and containing a few obscure plant fragments, large leaves, and a little resinous matter.

While this shale bears a close resemblance to some of those between the sub-nummulitic and overlying tertiary beds,—a large fragment of a leaf impression found here being to all appearance identical with those found in the former—the associated coarse light-coloured and red sandstones and flags are exactly similar in character to the upper jurassic rocks.

Fault.

One of the faults to the south by east would seem to strike directly for this place, and on the evidence of the leaf-bearing shale, the beds above it are supposed to be newer than the jurassic rocks, no such leaf fragments having ever been found in them.

Further down the same stream a cliff section exposes some nearly vertical beds with the usual *Nummulites* of the nummulitic rocks, overlying red and variegated clays which are in places gypseous, and a promontory jutting out into the Runn is formed of greenish, yellow, sandy and more compact earthy tertiary beds with intervening shales. These beds contain *Plicatulæ, Venus, Cardium* and other tertiary fossils. They are, however, much concealed by sub-recent concrete.

Nummulitic and other tertiary beds.

To the south-westward some rising ground is occupied by coarse red or white sandstones nearly surrounded by shales, and having undulating westerly and other dips at angles up to 25°. These sandstones from their great similarity to the jurassic rocks, in the absence of any evidence to prove them newer, are supposed mainly to belong to that formation and have been coloured as such on the map.

? Jurassic beds near Lukput.

In some gypseous reddish shales projecting from the south over a portion of this ground, there are thin ferruginous highly fossiliferous layers containing fragmentary oysters, *Corbulæ*, quantities of small bivalve casts, a *Voluta, &c.*, the casts being chiefly internal or not in good preservation, so that they could only be indefinitely supposed of perhaps eocene age.

Fossils in beds overlying them.

The occurrence of some rocks of cretaceous age here, with or overlying the uppermost portion of the Kutch jurassics however obscurely, would have considerable interest. The upper beds in the neighbourhood of Goonaree containing ashy bands, and the calcareous layer with *Belemnites* and shell fragments, differ in these particulars from the ordinary occurrence of sandstones, &c., similar to those accompanying these bands, but containing, as a rule, only terrestrial plant remains in other places. No better evidence of unconformity occurs than the single case mentioned (p. 234),

Rocks upper jurassic or cretaceous.

and the coaly shales with *Zamiæ*, &c., near Goonaree occurring in a position which (if not faulted would be apparently lower than these marine beds to the west-south-west and south) comes too near the latter to bear out the supposition that they represent higher beds of the jurassic formation than are elsewhere exposed, unless its thickness alters greatly; nor would it be safe on such evidence as exists to assume that any portions of the plant beds are of cretaceous age. These coaly shales occupy a place with regard to the lower marine fossil zone, just appearing at Sairee, somewhat analogous to that of the coaly beds near Trombow or the carbonaceous shales near Seesaghud; that is to say, they are separated from the lower fossils by a considerable amount of nearly unfossiliferous rocks; but this country, although traversed by faults, exhibits nothing to prove the existence of so large a downthrow as would be required to bury the great thickness of upper beds, without marine fossils, overlying the rocks at Trombow. If, then, these marine upper beds are as conformable to the rest of the jurassic series as they appear to be, it is probable that the upper group has changed greatly in its extension westwards both as to its thickness and fossil contents, while the rocks retain their usual aspect; this change with regard to the fossils being perhaps first indicated to the north of Oogulree, where a few probably marine shells were found as already mentioned.

Lukput.

The shales which surround the apparently jurassic rocks east-south-east of Lukput are red, variegated, brown, yellow and white, often ferruginous and interstratified with marls and laterites. Some deep crimson ferruginous boley beds are worked for exportation to form a red dye. Their upper portion on the northern side is a lateritic clay, which weathers away to a fine rusty dust.

This is succeeded by hard silicious sub-crystalline sandstone dipping to the north at 20°, immediately overlying which are the marly

calcareous nummulitic beds with a similar dip. They occupy but 50 or 60 yards in width, and have so small a thickness here (some 60 feet) as to render probable a continuation of the fault which brings them against the jurassic rocks further towards Goonaree. A layer of reddish marly rock overlies the nummulitic beds, succeeded by a partially consolidated sand bed of considerable thickness containing some large silicious rib bones overlaid in turn by greenish and variegated lateritic clay. These are the last beds seen towards the Runn, but some others, previously mentioned, come on further to the east.

Close to Lukput the dip changes to the west, and the nummulitic beds, still thin, undulate over the surface, forming ground of peculiarly barren aspect quite devoid of vegetation and thickly gravelled with nummulites derived from the marly beds just beneath. A small denuded hollow south of the fort exposes again the underlying gypseous shales, overlaid by the nummulitic beds, which, on the south side of this hollow in a cutting alluded to by Colonel Grant, are seen to change from a dip of south at 35° to horizontal.

The northern inclination of these beds just now mentioned extends to the town of Lukput, and is part of the small anticlinal described by Colonel Grant as passing through the town.

The same nummulitic beds spread over a large tract south and south-west of Lukput, the upper portion being characterised by an abundance of flat thin *Nummulites exponens*, or larger saddle-shaped forms, and the lower by a thick contorted variety, the lowest beds seen being the brown and yellow friable shales, with plant impressions, of the sub-nummulitic group.

South-west of Lukput.

Westward of this tract the higher level of the nummulitic ground declines towards the estuary of the Koree, where it is intersected by Runn-like recesses and much occupied by hills and hillocks of blown sand. In this direction, at one

or two places over which the sand appears to have travelled, ferruginous and silicious grit, supposed to overlie the nummulitic beds, occurs.*

The Runn-like portions of the shore of the estuary are said to be flooded only during the south-west monsoon, when the sea driven up by the wind helps to inundate the Runn.

South of Lukput.

The nummulitic rocks form a low semi-circular scarp facing the stratified trap hill of Bheti over Oomirsir. In the low ground at the base of the nummulitic beds some shales appear containing a band of small sized *Ostrea Flemingi*. This passes downwards into the highly ferruginous and gypseous shales with nodular bands of hæmatite, at the base of which are the strong laterites wrapping round the flanks of Bheti hill.

Oomirsir valley.

In the Oomirsir valley, the gypseous shales are particularly strong and are overlaid by alternations of red, white, gray and variously coloured ferruginous hæmatitic, sandy, and flaggy beds. In none of these beds were fossils met with except a few oysters in a gypseous shale north of Oomirsir, and about a mile and a half from the locality at which the doubtfully eocene forms previously mentioned were obtained.

South of Bheti hill.

In the river which passes near the southern end of Bheti hill, the nummulitic beds very nearly approach the trap, the strata of both dipping to the south at low angles, and the nummulitic beds being underlaid by 15 feet of unctuous, red, and purple mottled clay of the usual semi-volcanic aspect. Between this and the trap there is a blank space of 50 yards, so that the section is incomplete, but at a little distance to the east strong laterites rest upon the trap. Just to the westward from 40 to 50 feet of the white nummulitic beds are exposed in the river crowded with fossils, among which are *Schizaster* and several other *Echinoderms*, *Pecten*, and *Ostrea*.

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* In several places in this north-western part of Kutch, both on the shore and at some distance inland, local patches of the shells of *Pyrazus palustris* were met with as usual, in such a fragmentary state that a single perfect specimen could not be found.

The country south of this is an open plain covered by detrital deposits, concealing the boundary between the jurassic and overlying beds.

Gaira hills.

The hilly ground to which the name of the Gaira hills has been given for want of any other, has been regarded by General Sir Le G. Jacob as the continuation of the Abrassa chain, but it forms a much broader group attaining the most lofty elevations in Western Kutch. At the time when this part of the district was examined, a long continued drought had rendered the country so uninhabitable that much of it was deserted, and those parts only could be explored where water was obtainable. The examination was with difficulty carried round the base of these hills, and as they were always found to be composed of the bedded traps, it is believed that any details which may have escaped notice would not affect the general accuracy of the conclusions arrived at with regard to the structure of this part of the country.

The trap flows of these hills were seen in many places to undulate horizontally, the outer portion always passing with various inclinations beneath the sub-nummulitic rocks. The old surface formed by the flows appears to have had some irregularities, as hollows were found here and there occupied by the newer group, but not to such an extent as would indicate total unconformity. It could hardly be expected that such accumulations as the traps would everywhere present a perfectly level floor to receive the next deposits, but that they did so generally is shown by the persistence of the sub-nummulitic band along their upper boundary, whether locally thick or thin, and the conformity between the general inclination of the beds of both groups.*

* While it is admitted that perfect coincidence of stratification is no proof of conformity,—these same sub-nummulitic rocks and the jurassic beds of Eastern Kutch and the Runn Islands affording a striking instance to the contrary—it must be borne in mind, that the newer group of the locality under notice contains no such evidence of unconformity as would be afforded by detrital conglomeritic beds composed of trap fragments, while its connexion with the trappean group is strengthened by the occurrence of certain earthy rocks which must be looked upon as volcanic; specimens undistinguishable from them having been taken from intrusive *dykes* occurring either alone or associated with the doleritic traps of the interior of Kutch.

The traps of these hills form a large central area, round which, on all sides but one, the newer beds are arranged; their basal portion being as usual unconformable to the upper jurassic beds, but generally wanting the strongly marked line of escarpment which usually indicates the junction of these groups.

The flows are generally basaltic and more or less decomposed. They are occasionally strongly columnar as in the Panundrow river, a few miles south of the village, where the annexed sketch, Fig. 20, was taken.

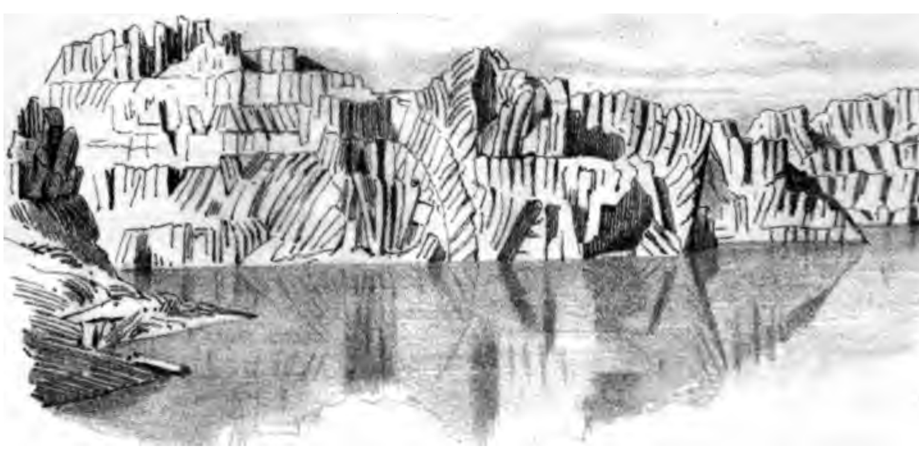

Fig. 20. Columnar basalt on Panundrow river.

Amygdaloidal flows are comparatively scarce, and one of the upper beds seen on the south-eastern hills is so ferruginous as to become conspicuous even at a distance.

Intertrappean rocks.

On the foot-road leading from Kora to Panundrow, not far from the former, some intertrappean beds occur within from 10 to 20 feet of the local base of the traps. They form a small pocket or irregularly lenticular band varying in thickness up to 20 feet, and are composed of whitish muddy shales, impure limestone and olive grit with strings of carbonate of lime.

They contain small fish scales, indefinite fragments of bone, a few small gastropods and bivalve shells, and some carbonised vegetable markings.

These beds, though clearly interstratified, do not occur between any two very distinct regular flows, those with which they are associated being porphyritic basalt and amygdaloidal trap, in places decomposed.

North-west of this place the traps appear to have been locally thin, as a small patch of the jurassic rocks is exposed not far from some of the overlying sub-nummulitic laterites, either forming a narrow synclinal or more probably let in by a fault. In the lateritic (? volcanic) clays here some very peculiar large concretions were observed, several feet in diameter, the centres being formed of basaltic trap surrounded by successive coatings of decomposed looking and ferruginous trappean rock, gradually approximating to the nature of the bed in which they are enclosed.

Large trap concretions in the lateritic beds.

The river which passes Dharisieu, not far from this, runs through coarse, rugged, ferruginous and light yellowish sandstones with white sandy and shaly beds, dipping to the south-west at 20°, but with a tendency to become horizontal. Between these and the laterite before mentioned a thin band of trap intervenes; its stratification could not be clearly seen, but the overlying laterite had a high dip to the south of west.

Jurassics, trap, and laterite.

Further down the stream its bank exposes the white nummulitic rocks. And nearer to Panundrow, some of the lower beds of the sub-nummulitic series are of thick, greenish, concretionary, cellular, and ferruginous ash, shaly in places, and sometimes of oolitic aspect, with some few carbonaceous spots. In such a position as to overlie these, on and in the north bank of the stream are gray gypseous clays weathering greenish, containing large bones and fragments of bivalve shells, some ferruginous layers being

Ash in the sub-nummulitic beds.

full of *Turritellæ*, &c. A lumpy lateritic bed overlies these, and is succeeded by the nummulitic marls and marly limestones.

Baboa hill.

Northwards from this place is the conspicuous elevation called Baboa hill, having a height of about 130 feet above the neighbouring stream, towards which it presents its steepest side, though everywhere almost precipitous in consequence of its bearing a thick capping of hard limestone.

This hill was erroneously supposed by Colonel Grant to have been locally elevated in consequence of the occurrence of some basalt in the river to the west. The structure of the ground is simple, the hill being formed by denudation, and the basaltic rock, of which but little is seen, most probably is a portion of the stratified trap which may fairly be presumed to underlie this country.*

The following section occurs in the river just beneath the hill:—

DESCENDING ORDER.

Beds nearly horizontal.

			Ft.
SUB-NUMMULITIC.	5.	Brown and yellow veined carbonaceous shales	4
	4.	White, concretionary pseudo-brecciated, saline, aluminous rock (? Lithomarge)	12
	3.	A whiter bed of similar character	2
	2.	Spongy, hæmatitic bed	2
STRATIFIED TRAP.	1.	Concretionary basaltic trap	11

A mass of greenish, rudely columnar, and partially concretionary basalt nearly at the same level as No. 1 continues northwards, with an irregular upper surface underneath the white argillaceous beds.

* Colonel Grant may have been misled by finding the nummulitic beds of the hill at a higher level than those in the adjacent plain. This is accounted for by the northerly dip of the beds in the plain on that side of the hill being a portion of some general undulations which affect the whole country.

Similar white beds occur from above the river banks to the immediate base of the hill, and there are remnants of a laterite band above them, better seen on its south side, together with strong gypseous shales. Above these rest the white nummulitic marls and marly limestone with shaly and sandy portions, as usual crowded with various nummulites and other fossils, among which the following were observed:—The large saddle-shaped *Nummulite* before mentioned, *Nummulites exponens, N. Raimondi, Alveolina, Cardium Picteti, Pecten Bouei,* d'Arch., *Conus—sp., Natica—sp., &c.* These beds have a thickness of about 80 feet, and are overlaid by the hard argillaceous compact yellow limestone before mentioned, in which numerous casts of bivalves and corals occur.

Kari Mori.

At a conspicuous hillock in the plain, west of Baboa hill, called 'Kari Moni,' the nummulitic beds are capped by a black grit which has been worked for mill-stones.

North of Panundrow.

In the stream northwards of the hill, the nummulitic beds have a northerly dip at an angle of about 4°, but the section is not continuously exposed. Here the upper beds of the group are yellow gypseous saline clays, and a soft, decomposed, gray and black sandstone with large *Nummulites*, also *Pecten Bouei,* and *Labadyei.* Above this are unfossiliferous, blue and yellow mottled gypseous shales with a thick bed of fine brownish earthy sandstone.

Further down the stream a synclinal curvature brings in some beds of a higher group, consisting of variegated sandy shales and rubbly beds containing *Turritellæ, Ostreæ,* and other fossils. These rest on red and yellow sandstone with abundant casts of *Natica,* and *Cyprea, Pecten corneus,* Sow., and large *Teredo*-like tubes, also with corals and fragments of *Echinanthus,* underlying all of which is a rough, highly ferruginous sandstone. To the north of this the opposite side of the synclinal is seen, the nummulitic beds again appearing with a southerly dip near the village of Byahw or Bayow.

South of and near Panundrow.

Near Panundrow village the ground is much covered by detrital deposits. The fact that erratics from the trap hills are numerous among these apparently led Colonel Grant to suppose that the bedded traps reached nearer to Baboa hill than they really do. In the river south of the village the basaltic traps appear in force, forming its high banks, and still further south a detached basin of the sub-nummulitic rocks occurs, the beds where plainly seen having sufficiently high angles to carry them above the neighbouring trap hills. At one place within five yards the following succession was observed:—

3.—Ferruginous red breccia interstratified with soft layers of white, smooth, earthy rock and containing nodular patches of the same.

2.—Blue, soft, ashy-looking gypseous band with amygdaloidal aspect,—? volcanic.

1.—Splintery amygdaloidal trap.

Some of the lateritic breccia here has a peculiar appearance, passing horizontally from a red to a greenish trappean-looking rock. It has greenish specks and a blotched concretionary structure, which on weathering gives the appearance of a conglomerate, containing large pebble-like blotches of white aluminous rock, and some of a compact dove-coloured calcareous earthy variety, this bed underlying brick red laterite. Some yellow, earthy, decomposed beds also seen beneath this laterite contain trap concretions of similar character, but smaller size than those already mentioned as found to the north-east of this place.

South-west of Panundrow.

Between this outlying patch and the low ground to the north-west, a rugged hollow on the outside edge of the trap hills presents a most peculiar variety of brilliant colouring; earthy laterites, and ferruginous breccia once continuous, being crossed by miniature valleys exposing the soft, purple, and white unctuous beds beneath, the whole under the influence of the weather assuming warm orange, red, black, bright blue, and pink tints strongly contrasted with the natural colours of the rocks, where seen unacted upon by the atmosphere.

The same sub-nummulitic rocks continue to the south-westward along the outward boundary of the traps, which here having low undulating inclinations to the north and north-west are occasionally exposed by denudation of the overlying rocks, and the soft lateritic deposit containing trap concretions again appears.

Nuriaree.

Some of the shaly beds which intervene between the nummulitic and sub-nummulitic groups appear in a stream bank, about 50 feet high, east of the village of Nuriaree, exposing the following succession :—

DESCENDING ORDER.

Undulating, nearly horizontal.

	Ft.	In.
3.—Variegated soft clay shales	20-25	0
2.—Thin, black, impure gypsum band	0	2
1.—Olive, green, argillaceous and gypseous friable shales with bluish and yellow calcareous marlstone bands. (These bands and the upper part of the shales are crowded with *Nummulites spira, &c.*) They disintegrate rapidly into fine powder	25	0

These shales, together with the underlying group, occupy low ground to the south-west skirting the trap hills, and the outcrops of the nummulitic beds above them form a scarp of about 60 feet, edging an extensive plain to the northwards occupied by the latter. On the opposite side of this plain, over which the rocks are generally horizontal, these nummulitic beds assume a gentle inclination to the north-west, and pass beneath slightly rising ground formed of soft shaly beds with lateritic and ferruginous sandstone bands resembling those seen in the synclinal at the Panundrow stream north of Baboa hill.

Kapfoorassir and edge of the Koree estuary.

In the plain near Kapfoorassir the uppermost part of the nummulitic beds is composed almost entirely of coral masses. Further westward in the low Runn-like ground bordering the estuary, calcareous dull yellow raggy beds, largely composed of foraminifera and other organisms,

slope west at very low angles, in a bay-like recess eastward of a conspicuous sand-hill. The surface of one of these beds was observed to be thickly studded with several varieties of flat *Echinodermata*, among which are the following:—*Cœlopleurus Prattii*, *Echinolampas*, sp., *Schizaster Beluchistanensis*, n. sp., *Eupatagus patellaris*, and a few *Gastropoda* badly preserved.

Nariensir.

Similar rocks to the above re-appear at Nariensir with earthy sandstones and more or less rubbly beds, containing imperfect casts of bivalve shells. Overlying these are patches of dark limestone and ferruginous gritty conglomerate enclosing lumps of laterite. They contain ferruginous casts of *Turritellæ*, some sharks' teeth, oysters, *Balani*, and a few claws of small crabs, and suggested a doubtful unconformity to the lower beds.

The small patch of Runn-like ground east of Nariensir is thickly covered with salt during the dry season.*

Goer.

A strong calcareous conglomerate made up mostly of nummulitic debris, with fragments of the local tertiary rocks, conceals much of the ground in the vicinity of Goer. It rests with palpable unconformity upon all underlying rocks wherever sections have been found, and is supposed to represent either some of the uppermost tertiary rocks or the littoral concrete of Western India. No fossils except those derived from other rocks were observed in it here.

About a mile to the east of the village, it rests upon mottled sandy shales and gray silty clays, in which a few fossils occur, including the carapace of a very small crab, some long narrow spines of *Echinoderms*, and a few small shells like *Cardita*, *Corbula*, &c. These clays have a gentle slope to the westward, and beyond their outcrop to the

* A well in the talao at Nariensir, although sunk through the rock to a depth very nearly, if not quite, reaching the sea level, furnishes sweet water. Wells in a similar situation along the shore of the Runn are said to be generally salt.

east, some disintegrating marly beds, which are highly fossiliferous, pass downwards into the nummulitic zone in the following manner:—

Descending order.	Ft.	In.
10. Calcareous rubbly beds with *Pecten, Echinanthus profundus*, thorny spines of *Echinus? Palæocarpilius*, and a large globose crab, *Palæocarpilius rugifer*, Stol. (*See* Pal. Indica, Series vii).		
9. Pale yellowish marl disintegrating into fine powder, with small *Nummulina, Conoclypeus Flemingii*, a few *Pectens, &c.* ...	2	0
8. Clay shales with impressions and casts of small thin bivalves ...	1	0
7. Yellow earthy marl disintegrating, full of *Operculina?* small, with some larger *Nummulites* and *Echinanthus* ...	3 to 4	0
6. White nummulitic marl weathering into powder, with *Pectens, &c.*	4	0
5. Argillaceous shale, with casts of *fuci?* shells of *Pectens* and corals	3	0
4. Calcareous marl crowded with large, flat, and small smooth *Nummulites (N. exponens, &c.)*, also *Pectens*	0	6
3. Dark gray, soft sandy bed with *Nummulites*, mostly small	2 to 3	0
2. White marl made up of minute organic fragments with large *? Serpula* tubes	2	0
1. Passing down into white nummulitic rocks with *Nummulites, Pectens, Ostrea*, corals in large lumps, large *Echinoderms* sparingly.		

Gypseous shales near Booda.

Eastward, towards Booda, a deserted village on the most westerly extremity of the traps, the barren plain of the nummulitic group begins to rise into swelling undulations, and where the somewhat indefinite basal escarpment of these rocks conforms to the angular termination of the traps, friable blue and yellow nodular shales and gypseous clays appearing from beneath them with the general westerly dip overlie strong lateritic beds, beneath which come the *Operculina* marls and shales, as detailed in the section near Nuriaree. The sub-nummulitic band between these and the traps is here obscured by concrete of sub-recent appearance.

The most westerly exposure of the trap consists of a peculiar crystalline speckled variety containing much iron and possibly nearly associated with the lateritic rocks.

Barinda, sub-nummulitic, &c.

In the stream valleys below the village of Barinda, the soft many-colored beds of the lateritic or sub-nummulitic group appear as usual much decomposed and exhibit little or no regularity. A lateritic bed at one spot close to the base of the group bears some similarity to the ferruginous trap last mentioned. West of the village soft decomposed trap occupies low ground overlooked by a scarped rugged outcrop of strong laterite, dipping to the west-south-west.

The stratified traps of this neighbourhood form large dome-shaped hills overrun with splintery débris. In some of the trap ravines east of the village much sub-recent white calcareous concrete occurs. Its structure here being unusually oolitic. Many of the minute spherical grains are hollow, but nothing organic could be detected among them even under a microscope.

Westward of the rocky lateritic outcrop already mentioned the overlying gypseous shales can be traced, and the slight escarpment of the nummulitic beds here dies out, and the country which they form presents large, white, barren, open, undulations. Their dip is generally to the south-west at very low angles, and their lowest stratum is as usual characterized by the occurrence of a thick species of *Nummulite* *(N. perforata)* among other fossils.

(Koond district).

Gade Putar coral mass.

A conspicuous flat-topped hill called Gade Putar, about 100 feet in height, rising to the west of Khoodee (deserted), consists of a rugged mass of limestone, compact below, while its upper portion is almost entirely composed of coral and highly crystalline. This, although just beyond the nummulitic zone, may possibly be the remains of an old reef originating at the same period as the band of corals which marks its upper boundary.

Soft and harder dark and light yellow thick bedded sandstones with finer muddy sandstones occupy the country south of this hill. In a deep

ravine which crosses these rocks they are seen to dip to the west at very low angles and overlie the white beds of the nummulitic group, the shales which have been previously mentioned as intervening being absent here. The upper part of the lower group as seen here is highly fossiliferous, among others containing the same *Echinoderms* as near Kapfoorassir, a new species of *Eupatagus, Schizaster, Echinanthus, Venus granosa,* &c., &c.

The ground formed by the overlying sandy rocks slopes gradually seaward, and the coast is edged by sand-hills.

Peepur temple.

Beneath the sand-hills in the neighbourhood of Peepur temple, soft sandstones and calcareous beds dip at very low angles to the west, having among them some highly fossiliferous beds, one of which is a foraminiferous rag similar to that at Nariensir, another a band of branching corals beautifully weathered out, a third filled with *Turritella angulata,* together with numerous perfectly preserved crabs, *Palæocarpilius rugifer,* Stol., (Palæon. Ind. Ser. vii) and other fossils.

From this rock a slab containing large rib bones was collected, also *Venus granosa,* Sow., *Cardium triforme,* Sow., *C. ambiguum, Ostrea angulata,* Sow., and *multicostata,* d'Arch., a *Lithodomus, Echinolampas spheroidalis, Rostellaria Prestwichii,* a *Cladocora,* and several fragmentary corals and other fossils. A narrow band of ferruginous conglomerate similar to that at Nariensir overlies these beds with apparent unconformity. It contains oysters, *Rostellaria Prestwichii, Balani,* and *Teredo*-like tubes, probably of large *Serpulæ.*

Overlying this at one spot a still newer-looking deposit formed entirely of nummulitic débris occurs, similar to that at Goer and several other places.

East of Peepur.

The country to the east of Peepur and in the neighbourhood of Rutteepar is much intersected by ravines, but the succession from the nummulitic beds upwards

is obscured by a thick detrital deposit of similar character to that last mentioned. Some yellowish earthy sandstones are, however, occasionally seen, and numerous corals scattered over the fields on the east side of the latter village indicate the upper boundary of the nummulite group.

South-east of Peepur.

Just at the village of Peepur, soft, sandy, and earthy beds with a few harder calcareous bands are traversed by a strong 'reef' similar to those occurring in the jurassic rocks, but much less frequently seen in the tertiary formation. To the south it crosses some fine calcareous and shelly sandstone, probably lower in the series than the fossiliferous beds under Peepur temple, the outcrop forming a small escarpment traceable eastwards to the neighbourhood of Bayr.

Near Golai.

Some sandy hillocks rest upon the southern slopes of this escarpment, beyond which rocky ground exposes mottled marly clays overlaid by hard calcareous conglomeratic and flaggy beds containing only a few *Balani*, oysters, and shell fragments; these pass upwards into yellow, calcareous, rough, raggy marls containing *Echinoderms, Foraminifera* and *Bryozoa* similar to those found at Peepur and Nariensir, also *Echinanthus profundus, a Pecten, sp.* and other fossils.

A deep ravine with vertical sides 60 to 70 feet in height here opens to the sea, exposing only the detrital deposits previously mentioned, portions of which assume a concrete structure and occasionally contain large *Ostrea lingua* of very recent appearance. Beyond this ravine, in the low ground bordering the coast, a calcareous raggy bed containing *Turritella, Cardium and Arca* (?) is overlaid by 60 feet of gypseous clays, to which succeed some highly fossiliferous beds containing casts of *Voluta, Solarium, Turritella, Cyprea, Cerithium, Natica, Venus, Cardium, Strombus nodosus, Xenophora cumulans,*

Serpulæ, &c., together with whole bands made up of *O. multicostata* and *Placuna* sp.

This part of the coast is bordered by very high sand-hills extending more or less continuously from Nariensir to Ukree.

The highly fossiliferous beds just mentioned extend through the country to the eastward.

Ukree.

At the village of Ukree, rugged, yellow, earthy limestone nearly horizontal appears from beneath the sand-hills. It contains numbers of *Ostrea* and *Pectens,* casts of large *Strombus,* and forms a characteristic band frequently met with in the plains to the east. It occurs again near the village of Janor beneath the thick detrital deposit, largely formed of nummulites already alluded to, and which is very prevalent over much of this part of the district.

Friable fossiliferous beds underneath the former contain a band, in which small *Echinoderms,* such as *Temnopleurus Hookeri,* occur abundantly associated with fragments of coral, *Trochocyathus, &c.,* small *Echinanthus,* some *Cidaris* spines and a few shells.

Lower in the series are some earthy flags, with minute *Foraminifera, Cupularia, Nummulites spira, Pecten Favri, Oysters* and very small *Gastropodous* shells.

Ramwara.

Another fossiliferous band underlying these is associated with a compact arenaceous limestone and some soft sandstones near Ramwara old fort.

Leaf beds near Bayr.

Northward of this some lower ground is occupied by thick unconformable detrital deposits, beneath which in the neighbourhood of Bayr, a broad band of blue shaly clays containing the small crab *Typilobus granulosus,* n. sp., Stol. (Pal. Ind., Series VII, Pl. III, Figs. 3 to 5), and minute bivalves found on the same horizon as before mentioned east of Goer, is traceable for

several miles through the country. Resting directly upon these is a very irregularly deposited zone of variegated friable sandy shales, between the laminæ of which a variety of dicotyledonous leaves are locally abundant.

North-west of Bayr these beds were seen to pass upwards by yellow faintly mottled sandy rock underlying a 6-foot lateritic band into the yellow rags and calcareous oyster grits of the overlying group, while they rest immediately upon the upper beds of the nummulitic zone.

Arenaceous group.

Advantage was taken of the intervention of this arenaceous and shaly band to mark the distinction between the nummulitic and overlying fossiliferous group. It exhibits many internal irregularities of deposition, has an inconstant thickness, and in some places suddenly disappears, being absent over most of the ground hitherto described.

The open nummulitic country north and east of Bayr is traversed by steep rocky nullahs exposing only a few of the upper beds, which with wide undulations overspread the ground; they afford, however, good localities for collecting fossils, from which the following were obtained: *Conoclypeus Flemingii*, a *Spondylus*, *Vulsella legumen*, *Schizaster Beluchistanensis*, *Breynia carinata*, a *Crab*, a *Delphinula*, *Nummulites exponens* and fragments of corals of the *Isis* group, hitherto found only at Bayr.

Karray.

Rocks higher than the surrounding ones form a small patch on the river bank near Karray, which gives the following succession:—

5. Detrital rock, nummulitic débris, unconformable.
4. Dark-brown ferruginous soft sandstone with thin pebbly parting at base.
3. Pale-greenish, fine sandy calcareous mudstone passing down into—
2. Pale-greenish clay shale containing *Nummulina?* *Pecten*-like shells, square bodies? palatal teeth of fish.
1. Nummulitic rocks—coral zone.

Waieôr and Wagôt Section.

A stream which rises near Karray and passes by the villages of Waieôr, Wagôt, and Cheroperee exposes a fair succession of the rocks from the nummulitic upwards well into the argillaceous or fossiliferous group, thus:—

Descending order from near Cheroperee.

		Ft.	In.
30.	Soft earthy laminated beds with a thin band of hard calcareous sandstone.		
	(¼ mile break,—in which a marly bed was seen).		
29.	Brownish friable shales with bands of yellowish mudstone, minute *Foraminifera*, small *Gastropod* shells, *Placuna*, *Nummulites spira*, *&c.*	30	0
28.	Dark sap-green shale, damp	1	0
27.	Coarse rag made up of *Turritella affinis*, fragments of *Ostrea multicostata*, and other species of the same genus, *Placunæ*, resembling the recent *P. placenta*, *Tapes*, *sp.* (*Pullastra*) *virgata*, *Echinanthus* rib bones, &c.	1	0
26.	Calcareous fragmentary shell bed	1	6
25.	Liver-colored and yellow plastic clay	2 to 3	0
24.	Dark-greenish saline clay, with *Placuna*, a *Turritella angulata* band, and hard shelly layer of limestone	6	0
	(Break along strike of the beds).		
23.	Dark-yellow marly limestone shell fragments	} 100	0
	(blank space)		
22.	Thick and false bedded black shelly limestone varying to black and brown flaggy sandstone, with *Turritella angulata* and a thin band of white silicious sandstone		
21.	Yellow and greenish-blue mudstones alternating with earthy beds, about	10	0
20.	Rough rag with *Eupatagus patellaris*, *Cardium*, *Spondylus Renaulti*, *Cerithium*, *Nummulites spira*, *Turritella angulata*, fragments of crabs, *serpula* in tangled masses, branching corals, &c., passes downward into—	} 7	0
19.	Tough disintegrating marl containing *Ostrea*, &c., *Echinanthus*, *Modiola Subobtusa*, *Turritella affinis*, *Nummulites spira*, and coral masses		
18.	Mottled fine sand, purple and pink	35	0
17.	*Turritella angulata* band, fossils in yellow calcite	3	0
16.	Yellow marly limestone band with *Foraminifera*	4	0
15.	A bed of *Turritella*, in white calcite imbedded in yellow marly limestone	1	0
14.	Red ferruginous *Turritella angulata* band, corals, and *Echinanthus* ...	15	0
13.	Fine argillaceous sand, saline	100	0

		Ft.	In.
12.	Pseudo-conglomeritic concretionary bed with spongiform organisms, *Nummulites scabra*, *Tapes nonscripta*, *Pleurotoma Voyseyi*, *Natica*, &c.	3	0
11.	Blue, gray, argillaceous streaky sands with some soft yellow mud beds	20	0
10.	Ferruginous nodular beds with fossils, a fish tooth, a *Venus*, &c. ...	1	0
9.	Greenish silty beds with ferruginous concretions—more than ...	8	0

(Similar beds to these soft silty variously coloured sands undulate for a mile south of Waieôr. They are believed to represent the leaf beds near Bayr, for although no leaves could be detected in them here, these were found again in the next stream section to the eastward).

Some ferruginous sandstones at the village, with annelid tubes, are supposed to underlie these (No. 8); beneath them are—

7.	Pale yellowish marl stone and fine sands and plastic clays ...	20	0
6.	Marly sandstone with fragmentary shells	20	0
5.	Obliquely laminated red and purple soft mottled sandstone ? thickness	12	0
4.	Hard buff marly limestone, lower part rubbly, and white foraminiferous organisms, small *Pectens*, large *Gastropods* and bivalves, corals, &c.	10	0
3.	Yellow sandy marl, parts raggy, corals, &c.	8	0
2.	Brownish, gray, granular or oolitic soft sandy beds, part seen ...	12	0
	(Slight break).		
1.	Solid, white, marly limestone with much coral, the upper portion of the nummulitic series.		

The last bed is seen flooring the stream course north of Waieôr.

Plain north of Jukow.

The ground near Cheroperee, where the above section commences, is low, and passes gradually into the alluvial plain north of Jukow, in which the stream from the Teyrah and Mhurr basin seems to have wandered from an older channel.

Saheind hill.

The prominent hill of Saheind rises, by two or three terraces on the outcrop of its strata, south of the village of Wallusera, to a height of over 300 feet, sloping gently to the southward on the dip and with steeper declivities to the east and west. At the top of the hill is a black ferruginous gritty bed with hollow nodules, overlying a large thickness of soft yellow sand-

stones with hard compact flaggy beds. Under these is a strong four or five-foot band of rough calcareous conglomerate with shell fragments, polished ferruginous casts of a small crab, *Typilobus granulosus*, and *Turritella*, sharks' teeth, and palatal teeth of other fish.

The next bed below is a rubbly calcareous zone, crowded with branching, asteroid, and other corals, overlying another thick set of soft yellow sandstones.

North of Saheind hill.

The variegated sandy group intervening between these and the nummulitic rocks appears in the neighbourhood of Wallusera, forming uneven ground at a higher level than the plains to the east, or the nummulitic ground to the north.

Sandy beds containing leaves continue to the north-north-east, with open undulating stratification, their sinuous lower boundary passing near the villages of Gooaylah and Joonagea. At this line the nummulitic beds disappear, not being found in the country to the east, the manner in which they terminate north of Joonagea being complicated by faults and disturbances of the ground and further obscured by thick detrital deposits.

Near both of these villages along the boundary of the nummulitic rocks a similar bed to that numbered 2 in the last (Waieôr) section occurs here, containing, however, small *Nummulites* in abundance.

Joonagea.

Just below this bed, west of Joonagea, *Alveolina* are very numerous in a soft yellow sandstone resting on the white nummulitic beds, in one of which a number of vertebral and rib bones of *Mammalia* were found lying together, but in an imperfect state.

Not far from this near some hilly ground to the north-west, these nummulitic beds are seen to rest immediately upon strong pseudo-brecciated laterite without the intervention of the gypseous shales found a few miles further off in the neighbourhood of Wāg-ka-puddur.

The laterite varies considerably both in colour and texture, and the bed next above it is a thin calcareous band formed almost entirely of various corals confusedly mixed together.

Wāg-ka-puddur.

The ground north-east of Wāg-ka-puddur presents over a large space a complicated structure and peculiar aspect characterised by Colonel Grant as *"recently blown out"* at one locality, where much contortion and the effects of intense disintegration are only to be traced.

The relations are simply these. The rocks being sharply contorted, subsequent denudation has disclosed many small exposures of the traps surrounded by the variegated deposits of the lateritic group, and left only a few outlying patches of the succeeding nummulitic marls resting upon a strong bed of laterite directly superimposed upon the traps.

The following succession will illustrate the arrangement of the rocks:—

Descending order.

NUMMULITIC, I.	10.—Light yellow, compact, and rubbly calcareous and marly beds, nearly horizontal, and forming the basal escarpment of the nummulitic group. *Alveolina* and *Nummulites* abundant.	
GYPSEOUS SHALES, H.	9.—Soft brown shales veined with yellow ochre.	Probable thickness 60 feet; section not continuous.
	8.—Ferruginous, nodular band, *Placuna*, *Anomia elyros*, Gray, and *Ostrea Flemingii*, abundant, fish vertebræ, and portion of a reptilian jaw bone.	
	7.—Blue and yellow gypseous shales, in the lower part some concretionary hæmatitic layers, and one bed of brecciated ash.	
SUB-NUMMULITIC, D.	6.—Decomposed, gray, thinly laminated shales, rusty brown above, with ferruginous laminæ, in which a few leaves occur.	
	These shales are in places black, carbonaceous, and pyritous, and much resemble the alum shales of Mhurr. They contain small lumps of mineral resins and bitumen, also little horny scales, which may either be crustacean or fish remains.	
	Some of their lower friable beds are composed of impalpable dust of a pale buff colour (perhaps volcanic), between the films of which are numerous impressions of leaves.	

SUB-NUMMULITIC, D.—contd.

5.—Whitish pink, lavender, delicate green and cream coloured unctuous rocks (? volcanic).

4.—More highly coloured, mottled, and purple beds of similar kind with strings of hæmatite, part a pseudo-breccia' another extremely unctuous (? rock soap).

Average about 50 feet.

Numbers 4 and 5 are very irregular in deposition, without any lamination, and appear to be such accumulations as might have formed volcanic tufa. Portions of No. 4 contain rusty casts of small cubical crystals of ?pyrites.

3.—White earthy beds containing numerous spongy segregations of hæmatite ... ... 3 feet.

STRATIFIED TRAP..

2.—Greenish gray concretionary augitic trap, a few feet.

1.—Basalt.

Joolerai.

The above representative section having been compiled from Mr. Fedden's notes and observations made at different places near the hamlet of Joolerai north of Wāgka-puddur serves to show the general succession of the rocks, but is incomplete with regard to the laterite, which is very strong in this neighbourhood. This was only found resting locally, but directly on the trap, its usual place being just above the beds Nos. 4 and 5, but it is absent where these are best exposed.

The whole locality is particularly instructive as to the fugitive character of the base of the nummulitic and immediately underlying groups.

Where the nummulitic outliers rest upon the laterite here, the coral band to the westward of Joonagea previously mentioned is not observed. Neither is the *Placuna* and bone bed No. 8 of the above section seen, nor the gypseous and other shales with terrestrial fossils (Nos. 6 to 9) in which this occurs. The whole of the sub-nummulitic series from 3 to 5 inclusive is likewise absent, and the fossiliferous beds south of Baboa hill and in that portion of the series nearer Lukput—or at least their fossils—do not appear, while the laterite itself on which they rest is too capriciously distributed to claim any fixed position in the sub-nummulitic group.

This might have been supposed to result from unconformity, if the nummulitic beds were found to be derived from the underlying rocks; but this is not the case, and the succession which they exhibit in other places indicates rather that the absent beds have thinned out in this neighbourhood.

Samdiwari.

Very similar lateritic ground extends from this to the neighbourhood of Samdiwari, where a sheet of laterite from 10 to 20 feet thick occupies a slight synclinal depression of the traps and supports several small outliers of the tertiary rocks.

These outliers also exhibit the variable character of the rocks, some being composed of compact, pinkish-yellow, limestone overlying 20 or 30 feet of soft, yellow, and pale-blue shales, while in others the limestone rests directly on the laterite. As this limestone contains organisms characteristic of the uppermost nummulitic beds, it would appear that the deposition of the greater portion of this group did not extend to this locality.

Hekelu hill.

To the south of this beyond the southerly slope of the trap, the small but very conspicuous conical hill of Hekelu rises to a height of over 150 feet. Much of the intervening space is occupied by the lateritic group, which is, however, greatly concealed by superficial deposits, and close to the base of the hill are ferruginous and variegated soft thick-bedded sandstones, crossed by several lines of fracture accompanied by much disturbance. Fallen masses from the hill obscure its lower portion, the upper part being composed of strong finely compact grits which weather like limestone and have a blue colour internally. These rocks are not traceable in the vicinity, though from their nearly horizontal position and the height of the hill they must have a considerable thickness. It is therefore presumed that they have been brought into their present position by the occurrence of faults, which is rendered more probable by the complex

manner in which a small section of lower rocks disappears at a little distance to the north-east of the hill.

This section extends from the arenaceous into the sub-nummulitic group, and shows but feeble representatives of the intermediate beds which enter so largely into the structure of the country hitherto described. It is as follows:—

	Descending order.	Ft.	In.
ARENACEOUS GROUP...	14.—Streaky purple and white sands and shales ...	14	0
	13.—Hæmatitic band with mammillated concretions	0	4
	12.—Compact yellow clay-stone	1	0
	11.—Richly mottled red and purple sandy bed ...	6	0
	10.—Rusty, yellow and grayish shale full of ?*Nummulina* ... ... Lower part dark olive and sandy.		
REPRESENTATIVES OF NUMMULITIC GROUP.	9.—Muddy greenish gray shale		
	8.—Yellow and grayish sandy and rubbly beds with a dark brown granular or oolitic band—both containing the organisms of No. 10—in abundance, with a few larger *Nummulites* and *Pecten*	50	0
	7.—Soft yellow sandstones	3 to 4	0
	6.—Lateritic band	8	0
	5.—Yellow sandstones glistening on fracture ...	10	0
	4.—White and yellowish calcareous sandy marl with *Foraminifera*, corals, flat thorny spines of Echinoids, small Echinoderms, large casts of *Solarium* and *Serpulæ* tubes	10	0
	These fossils would indicate that the beds here are equivalent to the upper portion of the nummulitic rocks.		
	3.—Rough sandstones alternating with shale partings ... ... ?	6	0
	2.—Fine yellow sandstones decomposing to powder—with apparently the same fossils—? *Operculina*, as occur in the section near Nuriaree—a hard bluish slightly calcareous band at base ... ... ?	15	0
	(Break—20 feet horizontally).		
SUB-NUMMULITIC GROUP, UPPER PART.	1.—Blue and buff soft friable shale full of carbonaceous plant impressions with harder yellow ochreous layers, also containing fragments of plants ... ... ?	30	0

The lowest part of the traps, No. 2, Section A B, are olive and earthy, succeeded by the ordinary frangible basaltic kinds. These pass upwards into the sub-nummulitic, or lateritic series, No. 3, as follows, the junction being shown in natural order :—*

SUB-NUMMULITIC ...	6.—Red and white pseudo-breccia, earthy.
	5.—White, unctuous, and chalky clay.
	4.—A more pseudo-brecciated band with large white earthy blotches—probably volcanic.
	3.—White and red mottled bed, a variety of ferruginous ash with much silicate of alumina.
	2.—Pale purple lava-ash, a thin band.
TRAP	1.—Concretionary trap, or 'basalt wacke.'

These red and white earthy beds undulate in the stream course near the line of section and overlap a mass of coarse, soft, yellowish rugged sandstones exactly such as frequently occurs in the jurassic formation.—No. 1 in Section.

Southward of this the earthy brecciated rocks again appear, No. 3, associated with some highly ferruginous and hæmatitic black and red bands, both abutting near the section line against a protruding mass of jurassic sandstone marked upon the sketch map, Plate VI. Some of the white earthy rocks here contain scattered grains of quartz, and are associated with obliquely laminated, soft, red, white, and yellow sandstones much resembling the jurassic rocks.

At this place the traps have an undulating dip to the south at 5°, the flow in junction with the volcanic-looking earthy breccia being as usual spheroidal. One of the spheroids here was 8 feet in diameter, its centre being occupied by a cluster of smaller concretions. Another, measuring 3 feet 6 inches across, was occupied by the lavender, gray, unctuous, volcanic-looking rock with white specks, and the surface of the trap flow supported small patches of laterite.

* At a little distance east of the section here some sandstone of very jurassic aspect is seen at the place marked J upon the sketch map, Pl. VI.

GEOLOGICAL S

1. Jurassic 2. Tra
Cross Sect

Lithographed in Colors at the Surveyor

A few yards farther down the stream, a nodular or concretionary portion of the trap with a distinct but low dip to the south shows a transition into the soft unctuous beds by alternating rugged layers of greenish amygdaloidal trap with others of white and pink clay-? lithomarge—greasy to the touch. Some of the trap is earthy and soft, or vesicular, the cavities being filled with brown hæmatitic segregations or infiltrations.

Just to the west of this spot the jurassic sandstones appear in force at a little distance from the bank of the stream, where they may be either faulted or have formed an old cliff face against which the traps were deposited.

They also occur at the surface of the ground above, form a hillock traversed by small 'reefs,' and are seen in a well which has been sunk through them to a depth of 40 feet. They are here quite horizontal, consisting of light pink and variegated beds with one ferruginous layer 18 inches thick.

Following the section to the southward, a large oval hilly mound of dark trap (2) rises among the ravines and banks formed of the softer earthy beds No. 3, the lowest of the latter being a variegated, brecciated, thick irregular earthy band enclosing large concretions of ap, both these and their matrix having a highly decomposed appearance.

Alum shales.

Close to the southern end of this mound in a ravine or nullah coming from the eastward are situated the alum works of Mhurr. The soft deposits here have been greatly worked among, artificially disturbed, and exposed to the weather, but the variegated soft brecciated band last mentioned is that which contains the bed or beds worked for alum.

These are not exposed at the surface, but are reached by narrow pits and passages (barely large enough to admit the body of a man),

carried to a depth of 22 cubits. In these passages the alum bed is found to be an irregular deposit of black and gray shale, in places brecciated and penetrated by numerous veins of the lighter coloured overlying pseudo-breccia. Its dip could not be clearly made out, but appeared to have a southerly inclination, and the miners said, its thickness had never been proved, as the water from the strata prevented their being able to sink sufficiently low.

Portions of the shale brought to the surface contained numerous impressions of plant and woody fragments, small lumps of amber or mineral resin, with large but imperfect casts of monocotyledonous and many smaller dicotyledonous leaves.

The shale decomposes rapidly, and seems to contain less iron pyrites in the fresh portions than would have been supposed from the appearance of the weathered heaps, and some of the old workings are lined with exfoliating efflorescences of potash alum with a little saltpetre.

East of the alum works.

Eastward of the alum works the dark gray traps do not show much stratification in small exposures, but are seen on the hill sides to have a south-westerly dip. Their uppermost portion was found to be highly ferruginous and concretionary, and the overlying soft breccia, as elsewhere, contained large concretions with coatings of different degrees of hardness, the centres being formed of trap precisely the same as the underlying flow.

The soft breccia is as usual irregular, and passes upwards into more sandy varieties of ash (?) with a few coarse sandstone layers and thin bands of carbonaceous shale. Red and white variegated and pure white earthy beds succeed with bands of laterite, and, above all, are soft yellow clays and shales. In this direction, and indeed in many parts of the valley, the ground is obscured by the occurrence of sub-recent concrete, which is supposed to have furnished the highly calcareous specimens noted from this place by Colonel Grant.

Peculiar wells.

The fault which runs along the northern base of this hill strikes directly for a place where the southern corner of the jurassic sandstone exposure is enclosed on two sides by the traps. Here south of the Dhurmsala in the line of the fault a strong spring of warmish "*Kara*," saline water, fills a tank about 20 paces by 25 in extent, from which it is daily drawn for use at the alum works. It is said to replenish this every night, when the outlet is stopped, to a depth of 4 cubits. A steep bank of the horizontal jurassic sandstones rises a few feet from the tank. Close to the foot of this are several wells of good drinking water at about the same level as that in the tank, the nearest of them being but nine paces from the latter.

Leaf shales.

A narrow plain north of the hill from which this section starts exposes little rock, but the white and lateritic beds can be traced here and there; and some white sandy shales at Judwara talao on the road to Kora contain fine leaf impressions similar to those of the Mhurr alum shale.

Section E F.

Section E F shows the arrangement of the rocks to the westward of Mhurr and the place of some fossiliferous tertiary beds which are probably let down by a fault or faults on the south side of the basaltic trap ridge or spur, so as to have escaped denudation. The faulting was not, however, satisfactorily traceable; but the beds were seen to occur in the following descending order at a short distance to the west:—

Dip. S. at 5°.

	Ft.	In.
14.—Rugged yellow sandy beds full of fossils, small Oysters, *Pectens*, *Nummulites*, and Corals, *Venus nonscripta*, *Natica patula*, *Conus brevis*, &c.		
13.—Lateritic or ferruginous band	18	0
12.—Brown flaky shale, tough where not weathered, contains shark's teeth and ? *Nummulina*.		
11.—Yellow, earthy, compact bed	3	0

10.—Brown, soft, finely granular bed.

(Broken ground; the rocks concealed for a short distance; a fault probably occurs here).

Dip S. at 2°.

		Ft.	In.
9.—Light purple variegated clay		12	0
8.—Red ferruginous bed		0	9
7.—Dark variegated clay		10	0
6.—Shaly band		1	2
5.—Yellow, compact, earthy bed with nummulites		1	11
4.—Sandy gypseous shales		4	6
3.—Shaly band		3	0
2.—Red, sandy, mottled, somewhat ashy-looking bed		5	1
1.—Blue variegated clays, gypseous	more than	12	6

At a short distance below this a thin yellow band, such as No. 5, dips beneath the clay, and some large slabs broken from a highly silicious bed occur in a heavy bank of débris flanking the trap hill, while within one hundred yards to the northwards, the pale greenish gray traps, rudely columnar in places, are overlaid by some reddish, mottled, soft laterite or earthy beds, both dipping (so as to underlie the section above given) southwards at 20.°

The blue clay No. 1 is quite dry and full of carbonaceous and rusty remains of plant stems. It contains many prismatic and octohedral crystals of gypsum. The under surface of the yellow compact band, No. 5, is studded with crooked annelid tubes in relief, tangled with crystalline patches of gypsum.

Gypseous shales.

To the eastward within a short distance, the lower shales are highly gypseous, quantities of the clear mineral weathered out lying about the ground. On the northern bank of the stream, and further in that direction near the Alum store-house and boiling place, another fossiliferous band occurs overlying a black carbonaceous shale, and underneath another gypseous shaly band. The white earthy rocks of the lateritic sub-nummulitic series appear to the northward between these beds and the trap hill.

Lateritic and shale beds of this valley south-east of Mhurr.

Some low hilly ground well in the valley south-east of Mhurr exposes a nearly horizontal, hard, and very ferruginous red spongy-looking brecciated bed, the upper surface of which is strongly lateritic. It spreads over this broken ground, and underlies yellowish, olive, unfossiliferous earthy shales or clays. These apparently gain in thickness towards the centre of the valley, and are in places pale, purple, and gypseous with small carbonaceous layers.

The lateritic beds are very strong at the south-eastern side of the valley, forming a conspicuous red hill—Gatoree—not far from the trap boundary.

The laterite frequently appears in this neighbourhood surrounding some low basaltic trap inliers and occupying the space between them, and the remainder of the traps to the north-eastward. It is here associated with the usually accompanying white earthy rocks, forming, as elsewhere, rugged broken ground of brilliantly contrasted red and white colour. On the weathered surface of the smaller of these inliers marked (T) upon the sketch map, Pl. VI, very rich iron ore occurs, portions of which are limonite, of an unusual hexagonal form.

North-east and east of Badra, the laterite rises upon the flanks of the trap hills, forming strong crags and cappings on some of their lower spurs, associated with the lavender and white soft (? tufaceous) deposits, the latter being usually found in the lower situation. Just at the base of the hills, some white and mottled sands and shales with layers and concretions of hæmatite succeed the more volcanic-looking deposits.

The stratified trap hills of this neighbourhood are mostly composed of fine-grained solid basalt, amygdaloidal flows being rare.

SECTION 11.—ABRASSA.

The plains of Abrassa are the broadest in Kutch, including the open basin of the Mhurr and Teyrah rivers, where 'rain wash' and such superficial accumulations cause much difficulty in referring the slightly undulating rocks to their proper places. Here the nummulitic beds have disappeared, and while the sub-nummulitic group continues along the base of the hills, that which immediately succeeds it has been referred by Mr. Fedden, from the abundance and character of its fossils, to a place in the series above both the nummulitic and the next overlying but not constantly present group.

Connected sections do not occur of any length, and it will be sufficient to mention the most important localities.

Badra.

Between the locality last described and the village of Badra, not far from the base of the hills, some ferruginous and black sandstones underlie soft rubbly beds in which a few *Nummulites spira, and Cerithium ?sp.* occur similar to those high up in the series near Cheroperee. Just south of Badra a stream exposes a cliff section of 50 feet, in which is a yellow raggy, shelly marl interstratified with red and green sandy shales and other sandy beds. These are seen to be locally disturbed, changing suddenly from horizontal to a sharp dip of 35° to north by east. A general northerly dip is also traceable westward from this to the faulted ground in the neighbourhood of Joonagea and Sambera.

Near the latter village the streams on either side expose bright yellow rubbly marls with a few shell casts, beneath which is a bed of impure yellow limestone with *Clypeaster, Ostrea* and *Pecten* overlying

brown clay and sandy shale. Resting on the yellow rubbly marl just at the village is a small patch of rusty, ferruginous, ossiferous conglomerate containing chalky clay nodules. In this were found reptilian, (? tortoise), plates, and a number of large bones, among which were two fine molar teeth of *Dinotherium*.

Ossiferous bed at Sambera.

Less fossiliferous portions of the same bed occur sparingly in the neighbourhood.

In the country south of this, the northerly dip just now mentioned seems to form a portion of a broad anticlinal curve, bringing up arenaceous leaf-bearing beds, apparently a larger development of the band overlying the nummulitic group.

Arenaceous group.

Where the Mhurr river crosses these beds between the villages of Jungreea and Joonagea, its high banks expose a great thickness of light coloured yellow, pale blue, and brown sands, containing thin dusty laminæ with impressions of large smooth leaves, so fragile that good specimens could not be taken; among these beds are several ferruginous conglomeratic bands. The beds undulate with a general dip to the north, and are succeeded by the fossiliferous group, including a rubbly bed full of *Nucula*.

Another containing *Turritellæ* and some rubbly calcareous shelly sandstones and shales, with a *Placuna* bed, broken rib-bones, *Natica*, large *Solen ?*, *Nucula*, *Turritellæ*, (*T. angulata* and another), &c., and little crabs often enclosed in hard clay nodules.

Some compact calcareous sandstone caps a hillock called 'Aio-bett' south of the village of Bootta. The 'bett' is formed of soft, sandy, and argillaceous shales with thin yellow compact layers and a strong highly ferruginous lateritic band. In one of the small rain channels on its side, some large mammalian bones were found apparently washed out of the adjacent beds.

Bootta.

Below the shales is a rubbly shelly rag overlying yellow marls, both containing *Turritella angulata, Ostreæ, Placuna, Spondylus,* and other bivalves.

About a mile further west in another 'takree' (small hill) called 'Eyera bett' similar rocks contain the same fossils, together with *Scalaria, Natica, Cyprea, Cidaris,* spines and crustacean fragments. All these beds form somewhat high ground, extending east and west with a broken escarpment on their outcrops facing northwards.

Soojapoor.

In the neighbourhood of Soojapoor, the country is traversed by large streams with many deep tributary nullahs exposing disconnected sections through the gently undulating rocks which have a general tendency to dip southward. The following beds were observed, the thickness not being always apparent, and the succession of some bands doubtful, but all belonging to the same group. Some of the exposures exhibit the very variable nature of the deposits, apparently the result of accumulation by strong currents alternating frequently with more tranquil conditions :—

Descending order.

		Ft.	In.
11.	Band of yellow, hard, coral limestone overlying—		
10.	Thick shales forming a river cliff	60	0
	break.		
	Calcareous marlstone with large oysters	0	0
	(This bed was overlaid by some conglomeritic concrete containing fragments of the same rock and a few oysters. It occurred in the river bank only and may be unconformable).		
9.	Hard shelly calcareous mudstone containing *Ostreæ, Placuna, Echinanthus, Turritella angulata,* a *Balanus,* beautiful specimens of a *Cupularia,* one palatal fish tooth, &c.		
8.	Gray shaly clay with compact bands and a mottled, yellow and pink, rugged mudstone, band 7 feet thick with bored nodules ...	65	0
7.	Tough, ferruginous, yellow calcareous claystone, saline, thick and solid, weathering rapidly on surface, with broken fragments of *Echinanthus* and some *Nummulites spira.*		
6.	Oyster and *Placuna* bed, yellow, raggy, coarse, and shelly ? the same as 9 brought in by undulation.		

Ft. In.

5. Thin, brownish, red, ferruginous nodular sandy bed.
4. Brown ferruginous sand.
3. Here a 50 feet cliff, chiefly of greenish variegated shales. The upper 10 feet, a gravelly conglomerate of irregular thickness, deposited on an uneven surface, under which is yellowish and red dark slantingly oblique bedded sandy shale and clay, the lowest band being sandy; 20 feet seen 50 0
2. Another yellow, calcareous, marly bed full of small *Anomia ?*
1. Brown strong sandstone with fragments of bone.

The beds 2, 6, and 9 are all very similar, and the irregularity of those with which they are associated suggested the possibility of their being the same, but it is quite as possible that they may be three different beds; the shells in No. 2 were smaller than in the others. The clay or shale bands in this country seem to be more than usually thick, and some hard bands about the coral zone No. 6 form an indefinite escarpment extending to the eastward.

Woostea.

Flaggy sandstones and soft concretionary shales, with calcareous bands containing pectens, oysters, and other broken shells, lower in the series than the above, form small detached flat topped hills in the neighbourhood of Woostea and Goa.

Trummo.

In the channel of the Zeyrah river near Trummo, Rampoor, and Wursur some of the most highly fossiliferous beds of the group occur. They consist of thick gray shaly clays alternating with several bands of rough, yellow, marly limestone. The matrix of the latter disintegrating rapidly leaves the fossils in high relief, and in a fine state of preservation on the surfaces of exposed slabs. Many of the shales are also equally fossiliferous. Of the *fossils* collected hereabouts, 14 genera were *Gastropods* and 17 *Bivalves*, together with *Crabs*, *Balani*, *Serpulæ*, *Corals*, *Bryozoa*, *Echinoderms*, and fish teeth. Amongst them are *Xenophora cumulans*, *Solarium affine*, *Cerithium rude*, *Retepora*, *Cupularia*, *Oliva pupa*, *Venus granosa*, *Nucula*

Studeri, Rostellaria Prestwichii, Arca peethensis, Pecten articulatus, and Bouei, Pectunculus pecten, Placuna sp., *Ostrea tubifera,* species of finely reticulated *Pyrula, Trochus cognatus, Strombus nodosus, Cardita Dufrenoyi, Voluta dentata, V. Edwardsii, Terebellum distortum, Conus brevis, Natica patula,* an *Oculina, Cyprea elongata,* &c., &c.*

Nullia.

The ground in the neighbourhood of Nullia is an open alluvial-looking plain, the surface of which is strewed with rolled fragments of silicified wood.

The streams, however, near the village expose gray, olive, and purple shales, flaggy in places, with yellow, harder, calcareous and marly bands. These undulate at low angles, and are overlaid by very thick bedded, soft brown sands (portions of which are solidified by calcareous infiltrations), with clay nodules and cylindrical bifurcating concretions. The sands appear to be the prevailing rocks of the country, and exhibit various unconformable junctions with the beds below, their basal portion being generally conglomeratic, and bands of the same occurring also at higher levels.

In the sands, large logs of decomposing fossil wood occur. The cores of these are silicious, and may have furnished the rolled fragments found over the surface of the ground. The beds beneath contain but few fossils, some univalves, a large pecten-like shell, annelid or crustacean tracks, and indefinite fucoid impressions only being found.

Between the Nullia and Kotara rivers the plain is flat, or slightly undulates, and the boundary between the alluvium and the newer tertiary ground being exceedingly indefinite has been somewhat arbitrarily drawn.

* In Colonel Grant's paper several references are made to a village called Soomrow, and one of his shells *(Pecten Soomrowensis)* is named after it. He describes it as ten miles north-east of Jukow, but no village of the name could be found, and it is conjectured that Trummo is the place meant.

To the south of the Teyrah river and west of that town, the surface of the gently swelling ground is sheeted with a gravelly conglomeritic sub-recent looking deposit of considerable thickness as seen in the ravines towards the river bank.

Teyrah.

The junction between the Nullia sands and the shales beneath was again observed in the river bank near Teyrah, thus—

		Ft.
	Gravelly concrete, same as to west of the town	6
UPPER TERTIARY	Soft earthy sands and sandstones with calcareous concretions, loose conglomerate at base	15
	Unconformity.	
ARGILLACEOUS GROUP.	Soft muddy clays and shales with claystone bands, a few casts of marine shells...	20

At a little distance to the north, these shales are more fossiliferous, containing *Ostrea, Pecten, Placuna,* fragments of *Balani, Bryozoa,* and smooth spines of *Echinoderms.*

Further on lower beds appear, containing some gastropoda and including a *Turritella* band. Below these are 20 feet of clays, and in the bed of the next stream-course, they overlie a hard, yellow, marly limestone, rough with fragments of oysters and small pectens. North of this stream on a small rocky hill, brown, flaggy, impure, limestone full of hollow casts of shell-fragments has an unusually high dip of 70° to S. 30° E., becoming rapidly less on the outcrop side of the hill.

Kaunai.

Open ground extends to near Kaunai, where dark-yellow shelly limestones contain bryozoa and foraminifera with a few small *Gastropod* shells and spines. Over these is a considerable thickness of clays and shales containing many fossils and a shelly conglomeritic band with bored clay nodules, pebbles of sandstone, and polished hæmatitic gravel.

No univalves were observed in this locality.

Among these marine beds, and just above the shelly conglomeritic band, occurs a thick lenticular mass of mottled purple and whitish silt, containing abundant *exogenous* leaf impressions, but good specimens could not be easily obtained, as the leaves were more or less crumpled: and the rock does not open in parallel laminæ. Some yellow shelly marls and rubbly beds succeed, the fossils of which are but imperfectly preserved.

Leaf bed.

To the eastward at the base of the trap hills near Dubban, the lateritic or sub-nummulitic group is found in its usual place, but with a reduced thickness of about 50 feet. As observed to the east of Badra, the white and variegated lavender-colored, unctuous, portions seem to have occupied slight depressions in the surface of the traps which they immediately succeed, being distinctly overlapped by the harder lateritic rock forming here the prominent feature of the band. The saline mottled portion of the unctuous rocks here closely resemble the purple lava so frequently occurring in dykes crossing the jurassic beds.

East of Kaunai.

The trap flows of this neighbourhood are generally of the usual basaltic and decomposed varieties, augitic flows of greenish gray colour in their upper portion containing nodules of limonite. They dip generally towards the plains at low angles.

A peculiarly rugged craggy hill called Booraghur, between Koombree and Dubban, traversed by deep clefts, is formed of white, brown, and black quartzite, quite jaspery in places, apparently an altered condition of some of the strong jurassic grits.

This quartzitic variety of the jurassic rocks is sometimes seen capping hills as at Naithra 'bett' to the north-west; sometimes as in this hill the bedding is quite untraceable. Where forming ramps, it follows only the arrangement of their directions. In many cases the traps occur close by as a probable cause for the alteration, while in

others they may have been removed by denudation. Here, for instance, a peak seems to have projected into the surrounding trap, still the partial and isolated occurrence of these quartzites seems frequently inexplicable, unless by the supposition of some such agency as outlets of superheated steam.

Naithra.

South of Naithra a very sharp disturbance of the ground appears to have been accompanied by a fault cutting out the traps in one place, and in another concealing both these and the lateritic band. A smaller fault diverges from this south of Naithra bett, and the jurassic ground in the vicinity is greatly traversed by strong 'ramps' and 'troubles.'

In the neighbourhood of this line of fault, the jurassic trap, lateritic and tertiary beds, all dip steeply to south-20° to 30°-west, at angles averaging about 40°, that of the latter, however, rapidly becoming less.

These tertiary beds are raggy calcareous flags with broken shells of *Ostrea multicostata*, &c., *Bryozoa*, and *Cidaris* spines underlying clays and shales.

They appear to belong to a much higher place in the series than any of the basal groups to the westward.

Wumootee.

About Wumootee the trap beds are soft, amygdaloidal, and ashy looking, sometimes weathering of a greenish or purple colour, and they extend into the plain for a short distance instead of terminating at the base of the hills—an observation that applies generally to the country between this and Roha.

The tertiary outcrop forms a small scarp rising from the trap-ground, along which the lateritic representative of the sub-nummulitic group can be traced, though sometimes consisting only of a single bed.

The Wumootee stream exposes some variegated unctuous clayey rocks of this sub-nummulitic group, overlaid by a curiously tangled coarse concretionary bed, succeeded by a bed of yellowish-red laterite,

sandy and obliquely laminated above. Upon these rest yellow marly limestones, with *Oysters*, *Echinanthus*, sp., *Balanus sublævis*, *Natica*, *Corallines*, *Cidaris* sp. *spines*, *Schizaster Beluchistanensis*, *Echinolampus spheroidalis*, and *Vicaryi*.

Bitta.

Near Bitta this stream exposes some brown sands such as were noticed at Teyrah and Nullia, and little else besides superficial deposits is seen over these plains. Towards Rowa, however, the ground rises slightly, and the stream there shows a section in nearly horizontal beds, consisting of brown sands and sandstones above and lumpy concretionary clay beds among fine soft sandstones, beneath which a bright yellow claystone occurs. No organisms whatever were found in these beds.

The plain to the south of this shows an approach to the black soil of Western India.

Barachor.

Just south-west of Barachor the variegated soft rocks of the sub-nummulitic group appear in a stream, resting upon the traps, the upper flow of which is ferruginous and vesicular, weathering greenish and powdery. The marbled purple and white unctuous deposits above this have a thickness of 30 feet, are soft enough to be cut readily by a knife, and are traversed by veins and strings of red hæmatite. Above these is a laterite bed, blotched red and white, overlaid at a little distance by a band of fragmentary shell limestone, containing fossils similar to those found near Wumootee.

Roha.

On the southern slopes of the hills north of Roha, much of the trap weathers to a brownish dry earth. Thick flows of soft splintery rotten dark trap with concretions and lumps of harder nature overlie these, and at one place contain a (2-foot) bed of red bole, showing the dip plainly at 10° to S.25°W.

At Roha, on the flanks of the hill surmounted by the fort, is a quantity of sub-recent regularly bedded white conglomeritic concrete, very thick and sloping from the hill; it also occurs on the eastern slopes of a larger hill close by, separated from this by a deep gap, and it is worked in the neighbourhood for building purposes.

The bases of both of these hills are of the ordinary basaltic flows of trap of dark greenish colour, and columnar in the river course near their foot.

Resting upon this trap, as though perfectly conformable, is a massive 30-foot bed of red hæmatitic laterite, in places a pisolitic hæmatite, the smaller concretions of which sometimes weather out separately and are used by the native shikaris as shot. It contains impressions of woody plants. Over this is a 10-foot band of pink and purple aluminous rock, with a peculiar columnar or prismatic structure, overlaid by 50 feet of buff and pink coarsely crystalline limestone, containing, and in places quite full of, small *Nummulites*. This limestone on the larger hill contains some thorny spines of *Echinoderms* and very indefinite shell fragments.

A red laterite band surrounds this hill, and is traceable through the neighbouring country between the tertiary rocks and the traps.

Chitrana Hills.

The Chitrana hills are formed by an anticlinal curvature of the stratified traps, the axis of which declines westward, and in that direction bends horizontally towards the south. Denudation has excavated deeply along the eastern portion of the axis, forming an irregular valley among the lower flows, and leaving the highest portion of the hills formed by the southern side of the anticlinal.

In this valley the flows are chiefly amygdaloidal, including some scoriaceous volcanic breccia, while the outer beds of the hills are of the more solid dark basaltic varieties, the upper portions occasionally exhibiting a laminated or flaggy structure.

The sub-nummulitic or lateritic band can be traced all round the outer base of the hills, and at their western termination a small representative of the nummulitic group itself reappears, with some of its *Nummulites* and *Alveolina*. This is succeeded as elsewhere by a belt of sands overlaid by the argillaceous or fossiliferous group, which extends out into the plain until covered over towards the coast by the upper tertiary beds. On the north side of the anticlinal all the beds are more highly inclined than on the south, being sometimes vertical and occasionally displaced by faults from the village of Kotera westwards. South-west of Noondatur, however, on the northern side of the termination of the traps, the groups succeeding them are seen within a distance of 300 yards,* the beds having been thrown into nearly vertical positions. Their total thickness here hardly exceeds 800 feet, ? the full development of each group not being apparent; the nummulitic indeed has a thickness of but a few feet, and one bed only of laterite was seen below it. The beds of the upper group strike along the south bank of the river from Noondatur, with a dip of 80° northward, and on the opposite side an alluvial plain extends for miles.

Noondatur.

This northerly dip may be traced in the plain to beyond Sainra, where fine yellow calcareous sandstone, sloping at 10° to 15° to north-10°-west, contains finely preserved casts of *Cardium* sp., *Gastropoda* and *Corals*.

Sainra.

In these beds is a hard pink claystone band two feet thick, both rocks being quarried for building purposes. Softer sandstones and rubbly, lumpy, calcareous beds also occur in the neighbourhood, the former containing quantities of *Strombus nodosus*, *Cerithium pseudo-corrugatum*,

* It must be remembered that an unconformity is supposed to occur within these 300 yards, and many of the beds beside the greater portion of the nummulitic group are probably unrepresented in the section, so that 800 feet cannot be taken even to indicate the general thickness of the tertiary rocks in this part of the province.

and *rude, Modiola subobtusa, Pecten Bouei, Arca kurracheensis,* a great number of *Lithodomi* and *Jouanettiæ,* and corals of the *Isis* group.

This upper tertiary ground is slightly higher than the level plain of alluvium, extending along the coast and up to Jukow, nothing being seen at the surface except rubbly, whitish, earthy rocks and incoherent sandstones with a few harder calcareous layers.

Sand-hills fringe the coast, and at one or two places recent concrete is quarried from beneath high water-mark.

Vinjan and Sandan stream.

The Vinjan and Sandan stream exposes much rock in its banks, the upper tertiary beds undulating at very slight angles towards the south, but having so little individuality of character that they become difficult to identify exactly where small breaks occur, being, however, quite recognizable as distinct from the subjacent group. The following order is observed in ascending the stream commencing at Sandan :—

Natural order.

SUB-RECENT ...	Conglomeritic concrete largely made up of quartz gravel, (about 3 feet).	
	Unconformity.	
	Mottled, yellowish, red, kunkury, arenaceous and argillaceous deposits.	Thickness of these beds estimated at several hundred feet.
UPPER TERTIARY GROUP.	22.—Whiter and faintly mottled deposits of similar appearance without lamination.	
	21.—Mottled, calcareous, argillaceous sandstone with conglomeritic bands of kunkury nodules of considerable thickness.	
	20.—Whitish-gray sandstones with coarser concrete beds.	
	19.—Coarse, soft sandstones with concrete beds irregularly bedded.	
	18.—Nodular and irregular conglomeritic concrete beds, alternating frequently with coarse and fine sandstones, containing large *Ostrea lingua*, fragments of dermal plates, and a worn apex of a conical tooth. There is a frequent appearance of unconformity among these beds.	

UPPER TERTIARY GROUP,—contd.

Break.

(Similar concrete occurs in a stream near Doomra, where they contain the *Ostrea lingua* more abundantly).

17.—A large thickness of brown and gray strong sandstones, with calcareous layers near the base.

16.—Thin conglomeritic and ferruginous band.

Unconformity.

ARGILLACEOUS (OR FOSSILIFEROUS) GROUP.

15.—Sandy and muddy shales and clays, including a few harder sandstone bands and ripple-marked layers. The thickness of these is about 200 feet.

In the upper part a rusty sandy bed has numerous casts of a small *Cerithium* with some of larger size.

Lower down a rubbly band with small *Pecten*, *Ostrea* sp., and *Bryozoa* incrusting some of the shells; also bored claystone nodules.

Below these *Balani* in clusters abound in a shelly fragmentary layer.

14.—Highly fossiliferous shelly rags and marly limestones (2 or 3 feet thick) among rubbly and softer marly beds.

These beds include the scallop and oyster band, the *Conus* and *Volute* beds, and also contain *Naticar* sp., *Cyprea*, *Scalaria*, *Pecten*, *Solen*, *Echinoderms*, casts of large *Strombus*, *Serpula* tubes, &c.

In one of the lower marly beds *Placuna* abound, together with *Ostreæ* and *Echinoderms*.

13.—Mottled, pink, purple, and white sandy shales and muddy beds.

Break.

12.—Nodular, lumpy, pseudo-conglomerate band, among muddy and sandy shales, and dark-yellow, marly, hard beds with *Nummulites spira.*

11.—Yellow and rusty raggy beds with *Turritella* and *Nucula*? &c.

10.—Soft and friable, fine, streaky, sandy shales.

9.—More compact and somewhat flaggy calcareous sandstone and marl, parts largely composed of shelly fragments of *Placuna*; also containing *Nucula*, *Turritellæ*, *Nummulites exponens*, *N. perforata*, and *N. spira.*

Break (40 feet of sub-recent accumulations seen in the river cliff)

8.—Mottled, white, and red sands and soft gypseous clays, with two pseudo-conglomeritic bands of whitish clay nodules and ferruginous pebbles. The lower of these associated with a layer of black gypsum—a *Turritella* band.

7.—Mottled, richly coloured red, fine, arenaceous clay, ferruginous oyster bed at base.

ARENACEOUS GROUP.	6.—Mottled, red, and white sandy clay and soft silty shales with tubular casts, ? crustacean burrows. (Short break, section continued at base of hills). 5.—White and mottled sands and sandy silt with thin ferruginous compact clay layers.
NUMMULITIC GROUP.	4.—Bright and dull yellow marls and marlstone, with *Nummulites* and *Alveolina*. 3.—Saline, decomposing, ferruginous sandstone, coarse and obliquely laminated.
SUB-NUMMULITIC GROUP.	2.—Purple lavender and white aluminous volcanic deposits. Laterite seen at a little distance associated with these.
VOLCANIC ...	1.—Fine grained, dark-gray trap, slightly amygdaloidal, with a laminated or flaggy structure weathering with glistening greenish minutely crystalline surface.

Below the upper tertiary beds of this section some shaly and calcareous thinly bedded sandstones were seen to underlie them unconformably at one place, and some orange, yellow and pink marls were similarly exposed in another spot about a mile further up the stream. They are like those beneath the Nullia sands, supposed to belong to a higher portion of the argillaceous group.

Kotree.

Along the flanks of the hills east of where the above section terminates, the ground is much overrun with detritus or sheeted with sub-recent calcareous white grit; and at one place north-east of Kotree this rests upon a considerable thickness of coarse river conglomerate, composed largely of trap pebbles and boulders.

In the Kotree stream south of the village, tertiary rocks similar to No. 14 of the above section abound with fossils of the usual kinds.

From this slightly rolling plains extend towards the coast, near which they are overspread by alluvium, fringed as usual by sand-hills.

Near Bait the river bank of 50 feet exposes sub-recent deposits of pebbly and gravelly detritus more or less stratified, resting on some of the kunkury and nodular, conglomeritic and sandy beds of the upper tertiary group lying nearly horizontal.

Bait.

In the Laija river, nearly horizontal and rolling, faintly mottled earthy calcareous and sandy beds with layers of concrete extend from the latter village to Rajera and Burra Ruttria, and some of the fossiliferous beds of the underlying group occur at Badye, but are not traceable beyond a few miles to the eastward, being apparently overlapped by the upper tertiary beds.

Laija.

Eastern Abrassa.

The upper bed of the ordinary stratified traps near Chota Ruttria is a thick, soft, greenish amygdaloid, weathering rapidly and having an uneven surface. It is overlaid by strong red laterite and soft red shales, with small pockets of the white unctuous volcanic aluminous rock so frequently observed beneath the laterite. The strong laterite here is of a brick-like and pseudo-brecciated appearance. The boundary between it and the traps is most irregular, and the soft beds so completely weathered down that the relations are obscure.

Chota Ruttria.

The laterite is succeeded by a most heterogeneously assembled group of lenticularly and falsely bedded coarse, white, and conglomeritic sandstones with large grains of white quartz and pale purple, unctuous, mottled aluminous layers and lenticular masses, quite similar in character to the usual volcanic ashy beds associated with the laterite. In one of the coarse beds some ferruginous markings like fossil wood were observed near a place where small accumulations of dark shales with thin, crisp, ferruginous layers were interstratified.

The uppermost bed of the group is an olive and purple mottled earthy laterite, with more splintery fracture than usual and the well-known brown glazed surface.

The beds dip at about 10° in a southerly direction on the west side of the stream here, but to the east the laterites undulate at low angles over the equally undulating surface of the traps, widening out in consequence until the neighbourhood of Syree is reached.

Syree.

Here at the conspicuous peak called Chendamatha, the laterite is 30 to 40 feet thick and has a pseudo-conglomeritic form, many of the apparent pebbles being concretions, and it has some markings like woody plant fragments. This laterite rests on amygdaloidal soft trap without the usual white unctuous rock intervening, but at one place to the south-east there is instead beneath the laterite a harder yellow argillaceous band veined with strings of hæmatite, and near this some more variegated earthy aluminous rock occurs also below the laterite, which is crossed by large nodular veins of the same.

In the river south-westward of the village, white conglomeritic gravelly coarse sandstones with white clay patches and some bands of red conglomerate occur, very similar to the rocks near Ruttria or in the Mhurr valley, and not at all unlike some of the jurassic beds. These rocks are seen to follow an anticlinal curve with a steep dip to the north and less inclination to the south, the centre of which is occupied by a brownish purple band of shale 50 feet in thickness, crowded with matted impressions of exogenous leaves generally of small size and lanceolate form. As usual, the shale is very friable and the fossils difficult to preserve.

The white sandstones become variegated with purple and greenish-gray at top, and are overlaid by massive laterite. The river section ceases at this for a space, and the rusty olive shales of the tertiary rocks are next seen in the neighbourhood of Chota Badye.

Further east the lateritic series undulates over the low flanks of the trap hills, and some feeble representatives of the white unctuous beds underlie the red laterite. The group here may be considerably less than 100 feet in thickness, and within the space it occupies are some small exposures of the underlying traps, which appear in this neighbourhood to have possessed a somewhat uneven surface prior to the deposition of the laterite.

SECTION 12.—THE KANTA.

In this part of the country a considerable change in geological structure is observed. The greater portion of the tertiary rocks seen to the west disappears; the uppermost group, however, continues with somewhat different character, partially separated from the traps by a narrow band of the sub-nummulitic group which dies out to the eastward.

The stream sections here were with few exceptions unsatisfactory, their broad sandy beds with low or sloping banks exposing only here and there small outcrops of nearly horizontal rocks.

Bit Assambia.

In the neighbourhood of Bit Assambia the trap flows are frequently much decomposed, and their upper bed is of a peculiar greenish ashy variety with hæmatitic strings immediately succeeded by the laterite, which may be found in the neighbouring streams, and rises with a small escarpment running towards the village of Poonree.

Eastwards of Bit Assambia these lateritic beds form a low anticlinal ridge running in that direction, and where it reaches the Furradee stream, the mottled laterite having a pseudo-brecciated form overlies red-yellow and white unctuous aluminous beds with strong saline efflorescences.

South-west of Bit Assambia, near the village of Gooniassir, the lateritic beds are succeeded by raggy shales, overlaid by calcareous brownish sandstone with numerous annelid tubes. Above these are whitish muddy and rusty shales dipping to the southward, so as to underlie thick light-colored sands and sandstones at the village, among which are harder fine grained beds used for ornamental building.

Near Burra Assambia little rock is seen, but some mottled clays with grains of quartz were found in the river south of the village, underlying soft sandstones and rubbly earthy rocks.

Further south the whole country is occupied by alluvium.

Bhoojpur.

In the river bank at Bhoojpur below the superficial alluvium is a gravelly incoherent deposit (that might be considered an older alluvium); the upper part is mottled brown and white, with much lime or lumps of decomposed kunkur, beneath which it is red and earthy.

Geylra.

North of this at Geylra a strong calcareous grit occurs among faintly mottled, lumpy, earthy and sandy beds, undulating nearly horizontally, and containing broken and ill-preserved marine shells, including several *Ostrea, Pectens, Voluta, Turritellæ,* and some other *Gastropoda,* &c.

Beraja.

North of this the section as far as seen up to Beraja is as follows :—

Descending order.

UPPER TERTIARY.	7.	Soft white and earthy sandstones with clean, gritty, and gravelly beds.
	6.	Faintly mottled, lumpy, earthy, sandy and gravelly beds.
	5.	Nodular, yellowish-white, earthy beds with unctuous slicken-sides.
	4.	Gravel bed largely formed of polished laterite and lavender (volcanic ash ?) pebbles, matrix unctuous, 6 feet.
		Unconformity.
VOLCANIC SUB-NUMMULITIC.	3.	Laterite 2 feet thick, not always present.
	2.	Purple and lavender lavas, consolidated muds or tufas faintly spotted with white, parts strongly amygdaloidal, parts identical with the purple lava dykes of the interior.
STRATIFIED TRAPS, VOLCANIC.	1.	Decomposing brown trap, resting on purple trap also decomposed, both very amygdaloidal, associated with masses of hard basalt.

North of Beraja the traps rise into a strong east and west ridge with a scarp to the north, and comprise various kinds of decomposing and solid basaltic flows.

Bharaya.

Similar calcareous grits to those seen at Geylra re-appear at Bharaya to the east, their upper portion being coarsely conglomeritic with pebbles of decomposing trap,

agates, and ferruginous grit. The thickness of the rocks, as exposed in quarries, is from 15 to 20 feet.

To the southward in the direction of their dip are some rubbly gravels and tough argillaceous rocks with cylindrical kunkury ramifications, the uppermost bed being soft reddish-yellow and sandy.

These beds are not seen further south than the deserted village of Chota Bharaya, and alluvial deposits occupy the ground.

Similar upper tertiary rocks to those just now described are seen again near the village of Khanduka.

At Puttree the ground is low, formed of decomposing traps, and rising gently to the hills, here receding to the north. About a mile south of the town a small remnant of the laterite occurs.

Similar decomposed traps extend to the eastward, but south of Wowar the upper tertiary beds are again seen resting unconformably on a very uneven surface of the trap, which forms the bed of the stream there. The bottom bed of the tertiary group is here a coarse gravelly conglomerate with pebbles of trap and other rocks in a white limy matrix. It is but two feet thick, and is succeeded by five feet of white sandstone varying to gritty, with some shell fragments in the upper part. In some places between these an irregular layer of small fossil oysters occurs. These beds continue for some distance down the stream, gaining but slightly in thickness, and are overlaid by brown arenaceous clay, white micaceous thinly laminated silts, and red sandy earthy beds with conglomeritic gritty layers.

Wowar.

At the town of Buddresur, some hard coarse shelly grits and gravels, fine sandstone and conglomerate of the same group, occur, crossed by a line of disturbance along which some trap was seen, but too indefinitely to be determined whether

Buddresur.

as an intrusion or exposure of the underlying stratified traps. It is most probably the latter, as the tertiary beds must be locally thin and dykes are unknown in these rocks.

About four miles to the north-east of Buddresur somewhat rising ground formed of the traps separates the upper tertiary rocks from their extension to the eastward, and continuing in the low ground is found for a short distance along the coast. The rock is generally of the decomposing augitic variety, compact basalt being only seen at one spot.

Toona.

Westwards of Toona the upper tertiary rocks, similar in character to those already described, occupy two bay-like recesses, indenting the general boundary of the trap. They dip generally at very slight angles from the traps, and rest quite unconformably upon their denuded surface, the lowest beds being generally conglomeritic and containing trap pebbles, agates, fragments of laterite, &c., with which the oyster band of Wowar occasionally appears.

In the Sungul stream north of the village, some thick bedded yellow sandstones, parts of which are coarse and shelly, are extensively quarried for building purposes. This rock is traceable to the east as far as Toona Bunder, where it is more calcareous and flaggy.

In the banks of the creek west of Sungul, the trap just beneath the tertiary rock has a remarkably decomposed appearance, being highly ferruginous, variously coloured and veined with hæmatite. One or two large crystalline masses of pseudomorphous silica, ? after Aragonite, were observed in the trap.

The trap flows of the eastern portion of the Dora hills present the usual alternations of basaltic, amygdaloidal, and decomposing varieties; concretionary and basaltic trap frequently columnar occurs near their base. In the middle portion vesicular, amygdaloidal, and decomposed flows with a few agates, and some purple bands may be found succeeded

by less decomposed, basaltic and other augitic flows towards the upper part of the series.

In the valleys near Boor and elsewhere are extensive sub-recent accumulations of kunkury concrete, soft white grits and sandstones, and as usual black soil is found to occupy the lower situations, supporting the argument in favor of its derivation from decomposition of the traps.

APPENDIX.

PUBLICATIONS RELATING TO THE GEOLOGY OF KUTCH.

No. 1.—MACMURDO, CAPTAIN JAMES.—Report to Government of India, October 2nd 1815

" 2.—MACMURDO, CAPTAIN JAMES.—An account of the province of Kutch and of the countries lying between Guzerat and the Indus, &c. Transactions of the Literary Society of Bombay, vol. ii, p. 205 ... 1820

" 3.—MACMURDO, CAPTAIN JAMES.—Dissertation on the River Indus (posthumous). Journal of the Royal Asiatic Society, Great Britain and Ireland, vol. i, p. 20 1834

" 4.—BURNES, SIR A.—Memoir on the eastern branch of the Indus and the Runn of Kutch, containing an account of the alterations produced on them by an earthquake in 1819. Burnes' Travels in Bokhara, vol. iii, p. 309 1834

(No. 4 also includes an extract from Captain MacMurdo's manuscript memoirs on Kattywar, 1815, and a note on "Sindree" by Captain R. M. Grindlay from manuscript of 1808).

" 5.—BURNES, SIR A.—(Manuscript survey of Kutch. Lib. Roy. Asiatic Soc., London.)

" 6.—SYKES, LIEUTENANT COLONEL, F. R. S., F. G. S.—Notice respecting some fossils collected in Kutch by Captain Walter Smee. Transactions of the Geological Society, London, vol. v, p. 715, second series 1834

" 7.—GRANT, C. W., CAPTAIN (since COLONEL), BOMBAY ENGINEERS.—Memoirs to illustrate a geological map of Kutch. Transactions of the Geological Society, London, vol v, p. 289, second series; reprinted in Papers on Western India by Dr. Carter ... 1837

" 8.—BAKER, W. E., CAPTAIN, BENGAL ENGINEERS.—Remarks on the Allah Bund and on the drainage of the eastern part of the Sind basin. Transactions of the Bombay Geographical Society, May 1844 to February 1846, p. 186 ... ... Oct. 1844

" 9.—NELSON, CAPTAIN R. E., in letter to.—Notice of an earthquake and probable subsidence of the land in the district of Kutch, near the mouth of the Koree, or eastern branch of the Indus, in June 1845. Quarterly Journal, Geological Society, London, vol. ii, p. 103 ... ?

No. 10.—LYELL, SIR C.—Earthquake of Kutch described. Principles of Geology, chap. 27, p. 459. Edn. of 1853 1853

" 11.—THOMAS, R. H.—Selections from the Records, Bombay Government, "No. XV." Miscellaneous information connected with the province of Kutch" 1855

" 12.—CARTER, HENRY J., DR.—Geological papers on Western India, including Kutch, Sind and the Arabian Coast, &c., and an Atlas, edited for Government 1857

" 13.—SCROPE, G. POULETT.—Volcanoes. Notice of volcanic action in Kutch. Appendix, p. 404 1862

" 14.—DODD, C. D., LIEUTENANT.—Particulars concerning the Runn of Kutch and the country on its southern margin. Transactions of the Bombay Geographical Society, vol. xvi, p. 1, Bombay ... 1863

" 15.—DODD, C. D., LIEUTENANT.—Memorandum on the eastern portion of Kutch, called Wagur. *Ibid.* p. 7 1863

" 16.—JACOB, GENERAL SIR LE G., C. B.—Extract from journal of a trip to Sind from Kutch in 1852 (by Colonel Sir Le G. Jacob). *Ibid.* p. 22 1863

" 17.—JACOB, GENERAL SIR LE G., B. C.—Extract from a journal kept during a tour made in 1851 through Kutch, giving an account of the alum mines of Mhurr and changes effected in 1844 by a series of earthquakes, &c., &c; also a letter accompanying this paper in the Proceedings. *Ibid.* p. 56 and xxxii 1863

" 18.—BLANFORD, W. T., A. R. S. M., F. G. S., &c., on the geology of a portion of Kutch. Memoirs of the Geological Survey of India, vol. vi, part 1, p. 17, at foot 1863

19.—GOVERNMENT CORRESPONDENCE, GENERAL DEPARTMENT, on the geological action on the south coast of Kattywar and in the Runn, accompanying an article in the *Bombay Saturday Review* of August 18th, 1866, from May 1867 to 26th of February 1868 1868

" 20.—SOWERBY, WILLIAM, ESQ., C. E.—Memorandum on the geological action as above. Transactions of the Bombay Geographical Society, vol. xviii, p. 96 1867

" 21.—SOWERBY, WILLIAM, ESQ., C. E.—Supplementary memorandum on above; also on the adjacent coast line as far as Kurrachee. *Ibid* p. 101 1868

" 22.—MEREWETHER, LIEUTENANT, R. E.—Report on search for stone for the Kurrachee breakwater in Kutch. Government Papers. ... 1867

No. 23.—RECORDS, GEOLOGICAL SURVEY OF INDIA, vol. ii, part 2.—Annual report, p. 31 1869

RECORDS, GEOLOGICAL SURVEY OF INDIA, vol. ii, part 3.—Preliminary notes on the geology of Kutch, p. 51 1869

„ 24.—CATALOGUE OF INDIAN EARTHQUAKES, by T. Oldham, Esq., LL. D., &c., Superintendent, Geological Survey.—Earthquake of 1819, Kutch; extent over north of India, Sultanpur, Oudh, Jaunpur, Chunar, Mirzapur and at Calcutta; also other earthquakes of Kutch, pp. x and xi 1869

„ 25.—FRERE, SIR BARTLE, K. C. B., F. R. G. S., LL. D., G. C. S. I., on the Runn of Kutch and the countries between Rajpootana and Sind. Report of the British Association for the advancement of Science, 1869, p. 163 1870

„ 26.—FRERE, SIR BARTLE, K. C. B., F. R. G. S., LL. D., G. C. S. I.—The Runn of Kutch and neighbouring region. Proceedings of the Royal Geographical Society, London, vol. xiv, No. 11, p. 120, abstract; see also Journal, vol. XL 1870

MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Description of the Geology of Nágpúr *and its neighbourhood, by* William T. Blanford, F. G. S., *Deputy Superintendent, Geological Survey of India.*

The neighbourhood of Nágpúr has become, through the writings of Voysey, Malcolmson and Hislop, and especially of the latter, one of the best known geological areas in the Indian peninsula. Its position precisely on the edge of the two great series of formations, the trappean and metamorphic, which, between them, occupy by far the larger portion of the Indian peninsula, gives to the locality a peculiar geological interest, which is greatly increased by the existence in its neighbourhood of several groups of sedimentary strata, and the occurrence of fossils in considerable abundance.

Until the season 1866-67, although the Geological Survey had been extended to within a comparatively short distance of Nágpúr, both on the north and the west, it had been impracticable to examine the very interesting formations in the immediate neighbourhood of the city, and to correlate them with the rocks containing similar fossils in other parts of India. It was especially desirable that this should be done in the case of the sandstone of Silewádá and Kámthi, because the fossils found in them by Malcolmson and Hislop were known to be similar to those occurring in the beds associated with coal in Bengal and the Narbadá valley. The practical results of the examination, so far as the probability of finding coal near Nágpúr is concerned, were published in the Records of the

Memoirs, Geological Survey of India, Vol. IX, Art. 2

Geological Survey of India for 1868, p. 26. A more detailed account of the rocks is given in the present paper.

It should be premised that, with the exception of the sandstone area, the country was not closely examined, as much important work remained to be done in the working season. No attempt was made at following out the intertrappean beds in detail, nor of mapping the various forms of metamorphic rocks.

Previous Observers.—It is unnecessary to enter into any detail in describing the earlier notices of the Geology of Nágpúr. The first was a paper by Voysey, "On the Geological and Mineralogical Structure of the Hills of Sítábaldí, Nágpúr, and its immediate vicinity," published in the Asiatic Researches, vol. xviii, pt. 1, p. 193; and in Gleanings of Science, 1830, vol. ii, p. 27. In this the basaltic rocks of Sítábaldí are the principal subject treated of, and the sandstones are scarcely mentioned.

Voysey: 1830.

The next contribution was by Captain F. Jenkins, As. Res., xviii, pt. 1, p. 195, in a paper entitled, "An account of some minerals collected at Nágpúr and its vicinity," with remarks on the Geology, &c., of that part of the country. This account which appears to have been drawn up with Voysey's assistance contains many details of the rocks, and is accompanied by a very fair Geological map. Malcolmson's well known article "On the fossils of the eastern portion of the Great Basaltic District of India, Trans. Geol. Soc., Lond., Ser. ii, vol. v, p. 537, added nothing to Captain Jenkins's account of the immediate neighbourhood of Nágpúr, but in a "Note on fossil plants discovered in the sandstone rocks at Kamptee near Nágpúr," published in the Journal of the Bombay Branch of the Royal Asiatic Society, vol. i, p. 249, the same geologist first announced the discovery by Lieutenant Munro of vegetable remains in the Kámthi sandstone. The fossils figured are species of *Glossopteris.*

Jenkins.

Malcolmson.

Hislop: 1853.

Nothing of any importance was added to the published information on the Geology of Nágpúr until the appearance of a description of the "Geology of the Nágpúr State," by the Revd. Mr. Hislop, in the Journal, Bombay Br. Roy. As. Soc. for 1853, vol. v, p. 58,* followed by Messrs. Hislop and Hunter's paper, "On the Geology and Fossils of the neigbourhood of Nágpúr, Central India," in the Quarterly Journal of the Geological Society, London, for 1855, vol. xi, p. 345. This admirable paper, the geological portion of which is entirely Mr. Hislop's work, is one of the most important additions to the Geology of India ever made by an independent observer. Although I am obliged to differ from some of Mr. Hislop's views as to the relations of the different strata, and although some additional instances will be pointed out in the following pages in which I cannot coincide with his results, it is a simple act of justice to acknowledge what a vast amount of aid has been afforded to the Survey by his published observations. The whole country in the neigbbourhood of Nágpúr and for many miles around in every direction, had been searched for fossils, so that, in many instances, in order to decide questions concerning the identifications of beds, it was sufficient to visit and examine a well-defined locality. The Survey in fact, in a similar case, is placed in the same position as Geological Surveys in Europe, and it is no exaggeration to say that the duties of the Indian Survey would be lightened and facilitated to an immense extent if every locality had received from previous observers the same close and careful examination which the neighbourhood of Nágpúr had received from Mr. Hislop, while the collection of fossils is an undertaking which can only be successfully carried out by a local observer, who can avail himself of such opportunities as may be afforded by quarrying, mining, road-making, digging for tanks, &c.

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* See also a Postscript to this paper in the same vol., p. 148.

Additional papers were published by Mr. Hislop "On the connexion of the Umret Coal Beds with the plant beds of Nágpúr, and of both with those of Burdwan" in Quart. Jour., Geol. Soc., Lond., 1855, vol. xi, p. 555; "On the ages of the coal strata in Western Bengal and Central India,"—Jour., As. Soc., Bengal, 1855, vol. xxiv, p. 347; On the tertiary deposits associated with trap rock in the East Indies, with descriptions of the fossil shells, &c.,"—Quart. Jour., Geol. Soc., Lond., 1860, vol. xvi, p. 154; "On the age of the fossiliferous thin-bedded sandstone and coal of the province of Nágpúr, India,"—*Ibid,* 1861, vol. xvii, p. 346; Remarks on the Geology of Nágpúr,—Jour., Bombay Br. R. A. S., 1861, vol. vi, p. 194; "Supplemental Note on the plant-bearing Sandstones of Central India,"—Quart. Jour., Geol. Soc., 1862, vol. xviii, p. 36, and finally, "Extracts from letters relating to the further discovery of fossil teeth and bones of Reptiles in Central India,"—*Ibid,* 1864, vol. xx, p. 280. These communications, each of which announced some addition to the previous knowledge of the geology or the fossil remains found in the country, were only interrupted by the writer's untimely death, by drowning, in 1863.

A Labyrinthodont amphibian found at Mángli by Mr. Hislop was described by Prof. Owen as *Brachiops laticeps* in 1854,—Quart. Jour., Geol. Soc., vol. xi, p. 37; some entomostraca tertiary and mesozoic by Prof. Rupert Jones,—*Ibid,* vol. xvi, p. 186, and vol. xix, p. 149; tertiary insects by Mr. Andrew Murray,—*Ibid,* vol. xvi, p. 182; and, lastly, the plants from Kámthi and Silewádá by Sir C. F. Bunbury,—*Ibid,* vol. xvii, p. 325.

Owen: 1854.

Jones: Murray: Bunbury.

The following is a brief review of the rocks around Nágpúr according to Mr. Hislop's classification as amended in his latest writings:—

I.—Superficial formations:—1, black soil, or regur; 2, red soil.
II.—Brown clay.
III.—Laterite.

IV, V, and VI.—Upper and lower trap and the enclosed sedimentary formation.

VII.—Sandstone formation.

A. Coarse thick-bedded sandstone with iron bands, subsequently considered the equivalent of the sandstone of the Máhádevá hills or Máhádevá group of the Geological Survey classification. To this group Mr. Hislop referred the sandstones of Bokhárá, Silewádá, Kámthi, and other localities northward of Nágpúr, and that of Báráogáon and Chookherí to the west and north-west, also that at the base of Sítábaldí hill. In one of his later papers, Q. J. G. S., vol. xvi, p. 159, Mr. Hislop classed this division with the traps.

B. Laminated sandstone or shale; subsequently considered the equivalent of the Damúda group. In this division, Mr. Hislop placed the laminated fossiliferous sandstones of Silewádá and other localities near Nágpúr, and also the red shale of Mángli. The latter Mr. Hislop subsequently considered newer than the laminated sandstones.

C. Red shale of Korhádí near Nágpúr, afterwards referred (correctly) to the Talchír group, but still later, Q. J. G. S., xx, p. 282, classed with the beds of Mángli and Maledi above the laminated sandstones.

D. White marble of Korhádí, &c.

VIII.—Plutonic and metamorphic rocks. The plutonic rocks Mr. Hislop considered as of later date than the sandstone formation.

Relations of these groups.

It is as well to mention at once that, besides the differences from Mr. Hislop's views on the history of the traps and intertrappean, which, in common with the late Mr. J. G. Medlicott,* I have already expressed in these memoirs†, the result of my examination of the Nágpúr country has led me to conclusions with regard to the relations of the sandstones differing from those of Mr. Hislop in the following points. With regard to Mr. Hislop's division A, I look upon the beds at the base of Sítábaldí hill and

* Memoirs of Geological Survey of India, vol. ii, pp. 206—208.

Dr. Carter was the first to suggest the idea of the trap beneath the intertrappean formation being a subsequent effusion,—Jour., Bombay Br. R. A. S., vol. v, p. 267.

† Vol. vi, pt. 2, pp. 152—155.

its neighbourhood as later in age than the coarse sandstones Bokhárá, Silewádá, Kámthi, &c. The former I class, as did Mr. Hislop in his later papers, as representatives of the Lameta or infratrappean beds, now clearly ascertained to be much newer than the Máhádevá sandstones proper.* The latter I associate with the 'laminated sandstone' of Mr. Hislop in a group which I call '*Kámthi*,' and which is, I believe, older than the Máhádevá group. To this Kámthi group I refer the rocks of Mángli and the mass of the Chándá sandstones, together with an immense mass of beds in the valley of the Godávari.† The red shale of Korhádí I consider Tálchír, and the white marble of the same locality I refer to the metamorphic rocks. The latter here, and throughout the plains of India, I believe to be of much older age than any of the unaltered sedimentary rocks found in the neighbourhood of Nágpúr.‡

General Features of the Country, Geographical and Geological.—The neighbourhood of Nágpúr has been so often and so well described by previous writers that it is only necessary briefly to point out its leading characteristics. The town stands upon the eastern edge of the undulating trap country, the cantonment and civil station of Sítábaldí being, for the most part, built upon the trap itself. The country to the west does not rise into hills of any great height, though it is interspersed with low ranges, and both these and the valleys between

* Mr. Hislop in 1859, Q. J. G. S., vol. xvi, p. 159, so far modified his views as to class the sandstone at the base of Sítábaldí hill with the overlying intertrappean, but he still considered it as the equivalent of the sandstones of Bokhárá and of the Máhádevá hills.

† See Records, Geological Survey, India, 1871, p. 49.

‡ It is only justice to Mr. Hislop to say that to any one unacquainted with the rocks in other parts of India, as Mr. Hislop was when he commenced his explorations, the Geology around Nágpúr presents unusual difficulties, from the circumstance that the greater part of the country is covered by alluvium, and that the rocks are only seen at all in a few isolated spots. Besides, when Mr. Hislop first wrote, scarcely anything definite was known of the relations of the different sedimentary formations; now, we have the advantage of some 15 years' study of them by the Geological Survey.

are covered with black soil, much mixed with stones. Near Nágpúr the greater portion of the country is cleared, but the amount of jungle increases with the distance from the station, until, at a distance of 12 to 15 miles, it covers a considerable proportion of the surface. Southward the country is similar to that to the west.

To the south-east, east, and north-east the surface is, for the most part, a plain covered with the alluvial deposits of the Kanhán and its tributaries. This plain extends to the north-east for some distance beyond Kámthi, and the sandstones near that station are only exposed in a few places on the left (north-east) bank of the river. To the north and north-west the same plain of alluvium is continued, but from its surface in several places, rise hills of sandstone and metamorphic rocks.

CLASSIFICATION OF ROCKS.—Excluding the soils and the alluvial deposits of the Kanhán and its tributaries, the following formations are found near Nágpúr:—

3. Trappean series	...	*b.*—Trap and intertrappeans. *a.*—Infratrappean or Lameta.
2. Sandstone series	...	*b.*—Kámthi group. *a.*—Tálchír group.
1. Metamorphic series.		

1.—METAMORPHIC SERIES.

As already observed, no special attention was paid to these rocks. They must occupy all the country to the east and north-east of Nágpúr for a great distance, but, near the city, they are, in general, completely concealed by alluvium. They are seen at the base of Sítábaldí hill around the railway station. Here the rocks are gneiss, very much decomposed at the surface, and it must be their decomposed appearance, and the resemblance to a soft sandstone thereby produced, which led Mr. Hislop to a belief in their being an altered form of the overlying sedimentary rock. They are also seen, but only for a very short distance,

At Sítábaldí.

in the Nág Nadi, about half a mile west of the spot where the stream crosses the Chándá road, and north of Sítábaldí they were detected in one place just north of the high road to Kámthi. To the east of the city the country was not examined.

Korhádí.

To the north of Nágpúr a low range of metamorphic hills commences about a mile east of Kámthi, and extends to Korhádí. The rock is chiefly a granitoid gneiss. The foliation to the eastward is about north-east—south west, with a dip to the south-east, but north and west of Korhádí village it runs north and south, and is vertical. At this spot a considerable quantity of crystalline limestone occurs, being the rock which Mr. Hislop described as a sub-division (D) of the sedimentary formation altered by the plutonic rocks of the neighbourhood.* The strike, as abovementioned, differs entirely from that of the gneiss a little farther to the east, but to the west towards Máhádúlá it changes again to the same strike as to the eastward.

Serpentine.

A little limestone, here containing serpentine, is again seen west of the small village of Máhádúlá, and again about a mile still further to the westward, rather more than half a mile south-east of the village of Gúmthulá.

Kolár river.

Gneiss is seen at intervals in the bed of the Kolár from the neighbourhood of the Korhádí hills to the village of Dáhígáon Rangarí. To the north of the Kolár the country consists of sandstone, mostly, however, concealed beneath alluvium, but near the Kanhán, and in the Pench, metamorphic rocks are exposed at intervals. To the north-west, they are best seen near Khápá and Kelod, where the strike is east and west and the dip south.

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* Mr. Hislop was probably chiefly induced to class this limestone with the sandstones from the latter having been considered by Voysey and Malcolmson representative of their "diamond sandstone" (the Vindhyan or Kadapá series of the Geological Survey Classification), which, in the Krishna and Godávari valleys and in Bandélkand, is associated with limestone.

There can be no reasonable doubt of the metamorphics around Nágpúr being an integral portion of the great series which occupies the greater part of the country thence to the Bay of Bengal. The age of the formations which have been altered into the gneiss, mica schist, hornblend schist, quartzite, limestone, &c., which are its principal constituent rocks, is quite unknown, but that they were all in their present crystalline condition, before the deposition of the Vindhyans, is clear, because the latter rest unconformably upon them, and contain rolled fragments derived from them, and the Vindhyans are of vastly greater age than the very oldest of the sandstone formations found at Nágpúr, for the latter, as will be presently seen, contain rolled pieces of the former. It cannot, therefore, be conceded that the plutonic rocks contemporaneous with the alteration of the gneiss have affected the sandstones found in the Nágpúr area.

2.—Sandstone Series.

a. Tálchír group.—Rocks occur at two places near Nágpúr, one of which there can be very little hesitation in assigning to the Tálchír group, whilst the other probably belongs to it. The only important exposure is that already referred to as the red shale of Korhádí, the type of Mr. Hislop's sub-division C of the sandstone series. This occurs between Korhádí and Bokhárá, about six miles north of Sítábaldí.

Bokhárá.

West of the Chhindwárá road, and north-east of the village of Bokhárá, grey clays and yellow sandstones are exposed in some ravines. They are, however, very ill seen, and all that can be said is that they are probably Tálchírs. Gneiss appears to come in beneath them, but close to the road, yellowish sandstone is again seen at the head of a small stream which runs to the north-east. The recurrence of the sandstone is probably due to a fault. Following the little stream across the road, hard calcareous red

shale is met with in places, dipping south-south-west. This is the spot at which Mr. Hislop obtained worm tracks.

In this stream the beds are somewhat decomposed, and have not the typical character of Tálchírs. But in a very small watercourse which runs from the north into that already mentioned, and which is just south of the little limestone hill immediately east of the Chhindwárá road, the typical fine silty shales are met with, breaking up into minute flakes, and only differing from the Tálchírs of Bengal and Orissa in their dull red colour. Calcareous bands, also of a red tint, and sandy layers are intercalated, as is frequently the case elsewhere. Pebbles and boulders abound, mostly surrounded by a calcareous crust: some are rolled, many angular; and besides metamorphic fragments, rolled and unrolled blocks of quartzite-sandstone and limestone from the Vindhyans* are abundant, and many of them are of large size. Pebbles of slate of unknown origin are also found.

'Boulder bed.'

Some huge blocks of granitoid gneiss, seen east of this, may be from the same boulder bed; but farther to the eastward no rocks are seen, and the whole country is covered with alluvium; so it is also possible that they may be masses *in situ*. To the north near Korhádí the metamorphics with limestone, as already described, come in beneath the Tálchírs.

Pátan Sáongí.

The only other place near Nágpúr where beds have been observed, which appear to belong to the Tálchírs, is north of Pátan Sáongí, 14 miles north of Nágpúr. All around the village is alluvial, but, about two miles north of it, a

* No Vindhyans are known to occur in the neighbourhood of Nágpúr. The nearest now existing are probably some hills lying east of Umred (Oomrair). But there can be little doubt of these Tálchír boulders having been derived from a distance as is so frequently the case amongst these rocks.

small isolated hill called Koda Dongrí, consists of pale buff argillaceous sandstone, very hard and compact, and containing pebbles of purple and white quartzite, and of very compact fine sandstone, all probably derived from the Vindhyans. It is far from clear to what formation this rock should be assigned, but similar beds are sometimes found in the Tálchír group. The stratification is vertical, striking east and west, and the rock is much cut up by quartz veins. Another small hill, rather more than a mile north-north-east of Koda Dongrí, consists of brecciated quartz rock similar to that found on lines of fault, and still farther to the north, near the Kanhán river, metamorphics are exposed.

b. Kámthi group.—No rocks which from their *mineral* character can be identified as belonging to the true Damúda formations (Barákar and Rániganj groups) of Bengal and the Narbadá valley, have as yet been found near Nágpúr. The beds containing coal to the south near Chándá, on the other hand, are similar in character to the Barákar group. The Kámthi beds, the relations of which to the Damúdas proper will be discussed in a subsequent page, occupy a considerable tract of country north and north-west of Nágpúr, a great part of the area being, however, concealed by alluvial deposits. They also appear in some inliers within the trap country.

Kelod.

The north-western extremity of the sandstone tract is at Kelod, where coarse felspathic grits are seen dipping to the north, in which direction they are faulted against the metamorphics. Very little is seen here, all the rocks being covered to the east and south-east by alluvium, while, to the west, both sandstones and metamorphics disappear beneath the trap.

Sáoner.

From Kelod to Sáoner, about six miles south-south-east, no sandstones are exposed. South of the latter place, brown grits and lilac clays or decomposed argillaceous sandstones crop out from beneath the traps with an undulating dip.

Thence to the eastward a long rise of sandstone extends, the beds being apparently horizontal. South of this, close to the village of Adúsa, there is a small hill, composed of rather soft grit, with a few thin beds of very fine compact red argillaceous sandstone,* or compact shale. The general dip of these beds is to the north. All the intermediate country between these few outcrops is occupied by alluvium.

Adúsa.

About five miles farther to the south-east, hills again appear, south and south-east of Pátan Sáongí, in a ridge stretching for about three miles from west to east, from the village of Chándá to Chicholí, close to Pádrí Khápá. The rocks consist of whitish argillaceous sandstone with lilac streaks, intercalations of red and yellow compact shale, and coarse gritty beds with conglomerate and bands of deep brown ferruginous grit. *Glossopteris* leaves are met with here and there in fine white argillaceous sandstone, the plant impressions being destitute of carbon and coloured red. Altogether a considerable thickness of rocks is exposed. The dip is irregular, the beds rolling about very much; but they have a general inclination to the south.

Plant remains.

West of the hill, near Pátan Sáongí and south of that at Adúsa, sandstones are exposed close to Sáilorí, and may be traced to the trap boundary near Walní and thence along the south edge of the igneous formations as far as Bokhárá six miles north of Nágpúr. The rocks here seen may be described before the remaining isolated exposures in the plain to the north.

Sáilorí.

* It is difficult to say what is the correct name for this rock. It is compact, and under the lens has the appearance of an amorphous limestone, which it also resembles in hardness and in its somewhat conchoidal fracture, but it is not calcareous. It appears to consist of very fine sand and clay. It has no shaley structure. Its original colour is sometimes buff, sometimes red; at the surface it is usually of the latter colour. It is a very well marked and characteristic rock.

The little hill south-east of Sáilorí is of sandstone; just south-west of the hill in the Chandarbhága stream, a small fault is seen apparently running north-west—south-east. North-east of this fault the beds dip to the north, while on the other side conglomerates containing quartzite pebbles and lilac shales, impregnated with carbonate of lime, have a high south-west dip.

Tondakherí.

The rocks of the rise near Tondakherí, about two miles farther south, are coarse felspathic grits, conglomeritic in places, with sandstones and fine red compact shale, which is more conspicuous here than it usually is. The beds are quarried to some extent, and are traversed by joints striking west-15°-north and north-20°-west and nearly vertical.

West and south of Tondakherí, the junction of the Kámthi beds and the trap is concealed by alluvium. To the south-east, the village of Walní is on trap, a very thin cap of which covers the little rise north-west of the village, and the sandstone crops out all round, except to the south. The uppermost beds of the Kámthi group here seen are purplish felspathic grits. At Khandálá, half a mile farther to the south-east, coarse grit, somewhat hardened, is seen, only a little appearing above the alluvial clay, and here, as at Tondakherí and Walní, the sandstone rocks have no definite dip, but roll about, for the most part, at low angles. They can only be traced here and there close to the trap.

Khandálá.

Bharatwádá.

Beds similar to those of Walní and Tondakherí are exposed at Bharatwádá and Gotaikhápá, or Chakikhápá, as the village is also called. No good sections are seen, but a few small quarries exist here and there; they are very small excavations, from which a few cubic yards of stone are removed for local purposes, and the excavations are then abandoned and allowed to fill with rubbish. South of Gotaikhápá a few poor sections of felspathic

sandstone are seen in a stream. These have a steadier south or south-south-west dip, which continues hence to the eastward as far as Bokhárá.

Bokhárá.

The rocks may be traced here and there along the base of the trap hill south-east of Gotaikhápá, and one or two ridges formed of them are seen just west of Bokhárá. This locality is of especial interest, from being one of those most frequently mentioned in Mr. Hislop's papers, and although no large exposure of the rocks takes place, those seen demand a somewhat closer description.

The Kámthis form a small ridge, stretching along the trap boundary, which here runs nearly east and west. Trap is seen resting upon them in the little isolated hill close to the village of Bokhárá, again a short distance south-west of the hill, and also at the base of the trap hill about a mile west of the village. In all these cases, except the first, where a few inches of silicious beds representing the infratrappean group intervene, the trap rests directly upon the Kámthi sandstone. West of the village, the uppermost beds of the latter are felspathic sandstones or coarse grits, often stained with iron. They are not calcareous, nor do they contain chert, as is usually the case with the infratrappean group.

The quarried beds which succeed in descending order have been well described by Mr. Hislop.* I did not, however, observe the angular fragments of fine sandstone which he notices as contained in them. The principal rock is a hard compact grit, with a peculiar vitreous character, and breaking with a conchoidal fracture. In the quarries to the westward, hardened shales, pale bluish grey in colour, rest upon this grit, and contain imperfect plant remains; and near the village, at the side of the road which passes south-west of the little trap hill already mentioned, *Phyllotheca* is found in some shaley beds. Mr. Hislop mentions a car-

* Quar. Jour. Geol. Soc., Lond., xi, p. 369.

bonaceous* bed at Bokhárá. This I could not find; here, as elsewhere, I was struck by the absence of carbonaceous matter even in the impressions of fossil plants.

Lonhárá. Gúmthula.

Of beds below the hard band of grits, very little can be seen. On the road from Bokhárá to Lonhárá, coarse felspathic sandstones are exposed; thence to Gúmthula, where metamorphics occur, all the surface is covered by alluvium. East and south-east of Bokhárá, also, no rocks are seen, the last place where Kámthi beds are exposed being nearly due south of the village. From this spot the trap boundary sweeps round to the south, and when sandstones again appear below it near Táklí and Nágpúr, they belong apparently to a different series of beds, which will be described presently.

Chicholí.

But if, instead of following the trap boundary from south of Pátan Sáongí to Bokhárá, the strike of the isolated hills already described as extending from Chándá to Chicholí be followed, after passing over a considerable tract of alluvium on the banks of the Kolár river, a very interesting low ridge of rocks is met with, on the same strike as those of Chicholí, exposed south of the village of Silewádá, and again, on the same strike, after another intervening tract of alluvium, a second exposure of similar beds occurs just north of the river Kanhán at Kámthi. Between the belt of Kámthi rocks thus exposed in these two localities, and the area occupied by beds of the same group near Bokhárá, the metamorphic rocks and Tálchírs of Korhádí intervene, apparently brought up by a fault. The two localities near Silewádá and Kámthi are those from which the bulk of Mr. Hislop's fossils were

Silewádá.

* Mr. Hislop's words are, "the higher laminæ .. exhibit .. an approximation to the "carbonaceous colour, being quite brown through the amount of comminuted vegetable "matter which they contain"—Quar. Jour. Geol. Soc., vol. xi, p. 557. The bed is again mentioned in the same Journal, vol. xvii, p. 347. I cannot help suggesting the possibility of the brown colour being due to iron or manganese.

derived, and from the latter the name of this group of rocks has been taken.

Silewádá.

As already mentioned, the exposure near Silewádá consists of a low ridge striking about east-30°-south, about three miles in length, and not more than 200 yards broad; the village of Silewádá lying north of the centre, and on the alluvium, with which all the country to the north and south is covered. The beds dip south-30°-west at an average angle of 15°; neither their top nor their base is seen, nor can their relations to the metamorphics, which appear at a considerable distance in both directions, be ascertained. It is most probable that the sandstones are faulted on both sides, the fault to the north continuing to Kelod in one direction, and to Kámthi in the other; but this is not certain, and can only be inferred from the apparent straightness of the line of outcrop.

Quarries.

Numerous quarries have been opened in the neighbourhood of Silewádá, upon at least four different beds, and these afford opportunities for examining the section to some extent, although the surface between the quarries is much concealed by the débris taken from them. The following is a combined section, made out partly from the rocks seen in the quarries, partly from surface measurements, aided by information obtained from the quarrymen, and, although only an approximation, it is probably nearly correct as regards the succession of the rocks and their average thickness:—

	Thickness in feet.	
1. Compact coarse gritty felspathic sandstone, light brown or grey in colour, containing one or more thin bands of fine purplish argillaceous sandstone, which is quarried in one place. This is the highest bed seen, the thickness cannot be correctly determined. ...	?	
2. Soft felspathic grit, very loose in texture, red, speckled with white, the top is not seen; in one quarry there is exposed a thickness of ...	15	0
3. Yellow and red gritty sandstone, slightly micaceous, with gritty ferruginous bands.	2	0

4. Greyish white sandstone, purplish in places, slightly argillaceous, varying somewhat in texture, being coarse in patches, though generally fine. 4 0

This is a good building stone used by the natives for temples, and large slabs are cut for gravestones. In another quarry, this rock is softer, much coarser, and more felspathic, but still quarried for building purposes.

5. Grit with hard ferruginous bands; no section seen, minimum thickness. 10 0
This bed is probably thicker and may include other bands.

6. Fine yellow (or deep buff) compact shale, becoming red near the surface. 3 0

A fine building stone used for ornamental purposes.

7. Grit and conglomerate, no section seen; it probably resembles the next. 50 0

8. Coarse ferruginous grit and conglomerate with irregular ferruginous bands as in 3 and 5; these bands are very hard,* and are evidently not due to original deposition, as they cross the bedding, and in one case a band was seen in the form of an oval. Conglomerate beds are dispersed throughout the rock. In one quarry there is seen a thickness of 25 0

9. Fine brown argillaceous sandstone, peculiarly laminated in places, with curved joints, nearly in the direction of the stratification, which contain a black mineral† (sesquioxide of manganese?). This bed is probably local. 0 6

10. Fine buff-coloured compact shale, much resembling 6, very similar to the bed containing *Estheria* at Mángli between Nágpúr and Chándá. The rock becomes red near the surface. It has been largely quarried. 4 0

11. Fine compact variegated lilac and grey sandstone, slightly felspathic, containing *Glossopteris*, &c., used for the floors of bungalows. ... 0 6
From this bed all the Silewádá fossils have been obtained.

12. Compact grey and purplish sandstone used for building, base not seen. ?

Bed 8 appears to be Mr. Hislop's bed A, and the underlying beds, his division B. It is difficult to account for his considering No. 8 the highest bed seen, unless he looked upon the fine-textured beds, 4 and 5, as repetitions of 10 and 11. But it is clear that all form one continuous series, one bed after another crops out with the greatest regularity. It is true that at the base of No. 8 there is slight irregularity of

* These are the "iron bands" of Mr. Hislop.

† This is perhaps similar to the brown bed observed by Mr. Hislop at Bokhárá.

deposition, as frequently happens where a coarse-textured bed rests upon a fine one, but there is no good reason for believing that any break in the sequence takes place, far less for assigning the rocks above this line to the Máhádevás and those below it to the Damúdas.

In a quarry nearly a mile farther to the west than the spot where the above section was measured, the coarse grit, No. 8, appears to rest directly on the *Glossopteris* bed 11, 9 and 10 being wanting or represented by a layer of argillaceous sandstone a few inches thick. The ferruginous bands in 8 are here strongly developed, and above it there is thick felspathic sandstone. To the east, the outcrop runs along the right bank of the Kanhán river for some distance, and one of the bands of argillaceous sandstone, apparently No. 10, is well exposed.

The above section is, on the whole, the best met with in the neighbourhood of Nágpúr; the rocks opposite Kámthi, though well exposed, being, on the whole, more concealed by alluvial clay. The details given afford a fair conception of the typical kinds of rock in the Kámthi group with one exception, the semivitreous grit quarried for millstones at Bokhárá.*

Absence of carbon.

At Silewádá, as elsewhere, there is a remarkable absence of carbon. All the plant remains are mere impressions, the substance of the leaves being replaced apparently by red ochre. It is difficult to say how far this replacement of carbon by iron peroxide may have taken place. The yellow and red compact shales may be an altered form of the compact blue and carbonaceous shales elsewhere associated with the Damúda rocks, which contain the same plants as those of Silewádá. This subject, however, will be discussed in the sequel.

* The hardness and peculiar semi-vitreous character of this rock might be ascribed to the neighbourhood of the overlying trap (not to hardening by heat, an effect which rarely extends more than a few inches, but to infiltration of silica); but a similar semi-vitreous rock is found elsewhere in the Kámthi beds far from the trap boundary.

The rocks in the quarries at Kámthi have the same dip as near Silewádá, and appear to be on a continuation of the same beds. It is therefore unnecessary to describe them in any detail.

Large blocks or separate portions of bed.

The quarry whence Mr. Hislop obtained most of his fossils is a little to the east of the high road from Nágpúr to Jabalpúr. The fossiliferous blocks which he looked upon as boulders derived from a lower bed appeared to me to be the remnants of a band of sandstone very similar in character to that (No. 11) containing *Glossopteris* at Silewádá, but, as is frequently the case close to the surface, a large portion of the bed has decomposed, and the remainder appears in the form of irregular rounded blocks loose in the soil. That these are in their original position, and that they form parts of one bed, is evident from their arrangement along one line, and from the planes of bedding in all being parallel. The forms of fossil plants are more numerous than at Silewádá. *Pecopteris* and other forms occur besides *Glossopteris*.

Chorkherí: Kútkheri.

No other exposure of Kámthi rocks has been detected in this neighbourhood to the south or south-east within the limits of the Nágpúr district, but within the trap area west and north-west from Nágpúr there are three inliers* of the same beds. Two of these, one being very small, are near the villages of Chorkherí and Kútkheri, 12 miles west of Kelod, the third is near the town of Bázárgáon, 20 miles west of Nágpúr.

Chorkherí.

The Chorkherí inlier is about four miles in diameter from north-west to south-east, and nearly three miles broad at right angles to the above. Except at the north-west corner, where some infratrappean limestone occurs, the only beds met with are Kámthi, the most common being the usual coarse

* These are all mentioned and briefly described by Mr. Hislop—Q. J. G. S., vol. xi, pp. 352-353.

gritty felspathic sandstone, conglomeritic in places, and often intersected by hard ferruginous bands with red compact shale here and there. No good sections are seen, and the country is covered with thick jungle. The coarser grits are quarried for millstones, &c. The rocks have, throughout the inlier, a tolerably steady dip to the north, which seldom, if ever, exceeds 5° to 10° at the extreme north of the field; and, consequently, amongst the highest beds exposed, a few plant fossils, principally *Glossopteris*, were found in a fine compact reddish sandstone. These impressions are red in colour, and devoid of any carbon as near Nágpúr.

Kútkheri.

The Kútkheri inlier is only 1½ miles south-east of that of Chorkherí. It consists of a mere ridge of rocks nearly a mile long, striking east-20°-south and projecting above the traps, the dip is to the northward. The beds are identical with those of Chorkherí.

Bázárgáon.

The Bázárgáon inlier is much larger; it extends 10 miles from east to west, and 5 from north to south. The western part, which is covered with jungle, is hilly, consisting of flat-topped rises of no great height, and between them valleys filled with sandy soil, in which no rocks are seen in general, even in the streams which traverse them. The hills are composed of horizontal or nearly horizontal beds of coarse white, grey and brownish grits, sometimes blotched and streaked with purple. These are more or less felspathic, and contain pebbles of quartz or quartzite scattered through them, occasionally in sufficient numbers to make the rock a conglomerate, and the ground in places is covered by the pebbles. Mica frequently abounds.

Ghorpúr.

Fine red and mottled compact shale similar to that of Silewádá is seen below the grits on the hill south of Ghorpúr. No rocks are exposed immediately beneath this, but grits, undoubtedly, underlie it, and appear on the lower ground not

far off. On the whole, the rocks of the western portion of the Bázárgáon inlier much resemble some of those seen at Sálbaldi east of Ellichpúr.

Lárái.

The rocks near Lárái about the centre of the sandstone patch are exactly similar to those seen further west, but instead of being horizontal, they dip to the south-west. From beneath them, south of Lonhárá, grits and red and yellow compact shales crop out, similar to those of Silewádá and Kámthi. These grits are not conglomeritic; they contain the usual hard ferruginous bands, fragments of which are scattered over the country.

Dhámná.

To the south near Dhámná scarcely any sandstone can be seen in place, but north of the village plenty is visible. The trap is well exposed outside the north-east boundary near the village of Ashtí, but thence towards Lonhárá all the rocks are concealed by alluvium, and it is impossible to say what are the limits of the sedimentary formations in this direction. They may extend towards Kalmeswar, but it is more probable that trap exists beneath the alluvium in that direction.

3.—Trappean Series.

At Kelod.

a. Infratrappean or Lameta Group.—Throughout the greater portion of the trap boundary between Nágpúr and Kelod, wherever the contact of the two series is exposed, the igneous rocks rest immediately upon the sandstones of the Kámthi group. At Kelod a thin infratrappean bed is met with. It is well seen about half a mile west of the town, resting upon Kámthi sandstones, and again to the north near Jáithgarh tank, where it overlies metamorphic rocks. The bed in each place is nodular calcareous grit or gritty limestone, and the thickness apparently does not exceed 10 feet, but perhaps it is more than this, and it probably varies. Down the stream which flows past Kelod, about 200 yards east of the small quarry, itself at the east end of the town, the Kámthi rocks are seen

faulted against the intertrappeans, but the junction is ill seen, and throughout the surrounding ground the rocks are concealed by alluvium. From this point to the immediate neighbourhood of Nágpúr, the only spot where any sedimentary rock was found intervening between the traps and the subjacent formation, was at the little trap hill close to Bokhárá.

Infratrappeans are seen on the edge of an inlier near Rámpúra, south-west of Kelod. Below the earthy trap at the base of the igneous rocks there is a foot of green marl and then $1\frac{1}{2}$ to 2 feet of red marl, both containing much nodular carbonate of lime; beneath these again apparently (the section is obscure) there is calcareous grit. Kámthis probably occur here, but they are not seen at the surface.

Rámpúra.

Along the edge of the Chorkherí inlier, as already mentioned, infratrappean calcareous grit is seen at one spot only on the north-west corner.* In the large Bázárgáon inlier, it occurs along the north-east boundary near the village of Ashtí, and thence for some distance towards Lonhárá. In both the above instances, the rock is the usual limestone with irregular nodules of chert.

There can be no doubt but that the sandstone seen below the trap at the eastern base of Sítábaldí hill also belongs to the infratrappean or Lameta group; it is a gritty tufaceous sandstone of a white colour mottled with red, and somewhat decomposed; the total thickness is not seen, but it is apparently less than

Sítábaldí infratrappean.

* About four miles north of Chorkherí, on the road from Nágpúr to Betúl, close to the village of Chicholí, there is a small inlier about a mile in diameter entirely composed of limestone, resembling the infratrappean bed. The rock is scarcely exposed, except in the small stream which runs west and north-west of the village. In places it is finer in texture and purer than usual, being free from grit and chert nodules, but in general it presents the usual character. The bed is mostly horizontal, but it must be much thicker than at other places. It is possible that this inlier is an intertrappean bed, the base not being seen, and the intertrappeans occasionally, though rarely, assuming the same mineral character as the bed at the base of the trap. But probably it is infratrappean.

20 feet. The upper portion does not appear to have been altered to any perceptible extent by the overlying trap.

Mr. Hislop, as already mentioned, considered that this sandstone passed into gneiss. The surface of the latter rock is so much decomposed that an appearance is produced of a change from the hard crystalline gneiss into the soft decomposed sandstone, but this is merely an appearance, and one not unfrequently met with. It is undoubtedly deceptive, and, for reasons previously mentioned, the gneiss rock must be considered as of long prior date to the sandstone.

The sandstone is well seen along the eastern base of the hill, but it is almost impossible to trace it round the southern end or amongst the houses and gardens west of the hill. There is, however, every reason to believe that it occurs there, and, as was pointed out by Mr. Hislop, it is exposed a little farther west in the Nág stream close to the bridge on the road from Nágpúr to Bisnúr and Umráwatí, and in some ditches near the stream. The thickness here appears greater than it is beneath Sítábaldí hill. The lower portion of the bed is again white tufaceous gritty sandstone, conglomeritic in places and mixed with chert, which does not occur east of Sítábaldí hill. Above the sandstone is a bed of very compact hard grit having a cherty or jaspery texture, and breaking with a conchoidal fracture, which does not appear to be calcareous.

The same jaspery bed is seen north of Sítábaldí in the fields lying to the north of the north-western branch of the road to Kámthi. Beneath it there is white gritty sandstone. A similar sandstone is seen in places beneath the trap of the rise on which the Táklí artillery barracks stand. The bed could be traced no farther north.

The occurrence of a few inches of cherty vesicular rock beneath the trap of the little hill close to the village of Bokhárá has already been twice mentioned. In neighbouring hills the same bed appears to be intercalated between trap flows.

b. TRAPS AND INTERTRAPPEAN BEDS.—It is unnecessary to enter into any details concerning the traps; as usual, they consist of various kinds of dolerite, varieties of basalt, melaphyr, and anamesite prevailing. The distinctions between amygdaloidal and nodular beds are more or less local; each in turn is found resting upon the other. Anything like a detailed description of the different forms assumed by the rocks of this series locally would be useless, and their general features have been discussed in a previous paper. Memoirs, Geological Survey, Vol. VI, pt. 2.

The intertrappean beds abound to the west of Nágpúr, but no attempt has been made to map them except near the boundary of the igneous rocks in the neighbourhood of the city. To have searched over all the country represented in the accompanying map for these little beds, which frequently do not exceed a few inches in thickness, would have taken far more time than could be devoted to the district, and would have led to no important result. The beds marked on the map may be briefly described, commencing on the north-west.

Dhápawádá.

The first outcrop to be noticed in this direction is about three miles north of Kalmeswar on the little isolated flat-topped hill south of Dhápawádá. The trap flow forming the top of the hill is nodular and of no great thickness, perhaps 30 or 40 feet in the centre of the hill, and 10 to 15 at the sides, the upper surface being of course denuded. Beneath this flow is a bed of argillaceous rock, distinctly altered, and with a nodular structure above, unaltered below; it is 4 or 5 feet thick where best seen on the north side of the hill, and abounds in casts of shells (*Paludina, Lymnea, Valvata, Physa,* &c.), mostly broken.

No intertrappeans are seen south-east of this hill until the neighbourhood of Bokhárá is reached. On all the low trap rises between the village and Mahurjharí, a thin band of vesicular cherty rock can

traced, precisely similar to that at the base of the little outlying trap hill at Bokhárá. In the next hill to the west this bed is 15 feet below the top of the hill, and 60 feet above the base of the trap, the lowest flow of which is here distinctly nodular, and only slightly amygdaloidal. The intertrappean band is seen as far as north of Pitaisúr, but near Mahurjharí, and to the west of it, it appears to have died out.

Táklí.

The localities near Táklí close to Nágpúr from which Mr. Hislop obtained so large a number of fossils are the next to the south;* one of these is just west of the artillery barracks: the bed is a greenish grey clay, or hardened mud, breaking into small polygonal fragments, and occasionally containing rounded pieces of a rock precisely similar to itself, probably decomposed trap. The whole bed appears to consist of trap detritus; it can only be traced a few yards in any direction, and Mr. Hislop's idea,† that it is a portion of a bed caught up in a lava flow, may very possibly be correct.

The other locality is farther west, south of the Rassala lines. The bed here is a fine muddy clay, and has also the appearance of being formed of trappean débris. It contains fossil shells in abundance. It cannot be traced to any distance, but this may be due to its position in a small ravine, as it is a well marked bed.

There is nothing to be added to Mr. Hislop's description of the freshwater bed on Sítábaldí hill.‡ It is another inconspicuous band. In the quarry at the base of the hill, there is an appearance of more than one flow of trap being included in the thick bed which forms the mass of

* I doubt if I could have found either of these but for their being shown to me by Mr. Hislop's old servant Virápá. Both exposures are extremely small, and the rock so much like decomposed trap that it is most difficult to recognise it; probably many similar obscure beds of very small extent occur in this neighbourhood.

† Quar. Jour., Geol. Soc., Lond., Vol. XVI, p. 158. Of course I do not admit that the whole intertrappean formation has been similarly transposed, as was maintained by Mr. Hislop. See Mem. Geol. Surv., Vol. VI, pp. 152—155.

‡ Quar. Jour., Geol. Soc., Lond., Vol. XI, p. 349.

the hill. There are vesicular bands which may be the surfaces of flows, but they are not very distinct.

Telingkhedí.

West of Sítábaldí, a thin argillaceous intertrappean band may be traced for some distance along the scarp which runs parallel to the road from Sítábaldí to Telingkhedí, and bounds the valley of the Nág to the north. This bed disappears, apparently by thinning out, at both ends, to the east near the station of Sítábaldí and to the west near Phultálá or Telingkhedí tank. It is probable that the thin band on Sítábaldí hill is on the same horizon, and that the two were formerly continuous between the traps now removed by denudation in the Nág valley. North of Telingkhedí the bed is a foot in thickness; it abounds in shells and remains of plants, and in one place a trap pebble was found imbedded in it; this pebble was much decomposed, and it is impossible to say whether it had been rolled or not.

This is the locality to which Mr. Hislop's description at pp. 156-157, and his figure 2 in his paper "on the tertiary deposits associated with trap-rock in the East Indies," Quar. Journ., Geol. Soc., Lond., Vol. XVI, refer. Calcareous bands traverse the trap in an irregular manner, and are considered by Mr. Hislop to be formed of the intertrappean bed dispersed and scattered by the injection of the igneous rock. Newbold* in a similar case spoke of the irregular bands as "kunkur," and evidently considered them to be due to the deposition of carbonate of lime derived from surface water in cracks. This is my own opinion also; similar bands are often found near the surface, not only in trap, but in sandstone, gneiss, and other rocks, and that they can scarcely be dispersed portions of the intertrappean bed is, I think, clear from the circumstance that the latter in this locality is not calcareous.

At the side of one of the small ravines north of the Telingkhedí road, a band of greenish jaspery porcelain rock, resembling a greatly

* Jour. Roy. As. Soc., Vol. IX, p. 33.

hardened clay, is seen in the middle of amygdaloidal trap; it is about a foot thick, and extends for about 20 yards, terminating abruptly at one end. Whether this is part of a sedimentary intertrappean deposit, or a concretionary mass, such as occurs frequently in the infra-trappean sandstones and limestones, it is difficult to say: it may either be part of a sedimentary bed caught up by a flow of lava or simply the result of segregation, like the irregular nodules of jasper and chert which are found both in the amygdaloidal traps and in the underlying beds. The latter appears the more probable view, because bands of jasper frequently occur too thin to have been carried forward by a lava flow without breaking into fragments, yet extending for several feet; but the band near Telingkhedí is an unusually large mass.

No intertrappean rock was seen around Ambághari tank, but there is a considerable quantity exposed about 3 or 4 miles west of Telingkhedí. Time, however, did not suffice for the close examination of the country in this direction.

GENERAL CHARACTER OF THE SEDIMENTARY ROCKS NEAR NÁGPÚR, AND THEIR RELATIONS TO THOSE OCCURRING IN OTHER PARTS OF INDIA.

Tálchír Group.—It was perhaps rather a lucky guess than anything else which led Mr. Theobald, my brother, and myself in the report on the Tálchír coal-field in 1856 (Mem. Geol. Surv., Ind., vol. i, p. 76), to point out that the clays of Korhádí, near Nágpúr, were probably the representatives of the Tálchír of Orissa. The view, however, was adopted by Mr. Hislop, though in some of his latest papers he appeared more inclined to consider the Korhádí bed as representing those of Máledi (Q. J. G. S., vol. xx, p. 282). The first view proves to be correct, and the same beds are much more extensively developed near Chándá.

It is astonishing that, over so large an area, beds of such trifling thickness as the Tálchírs should everywhere maintain their mineral

character with such remarkable precision. The description of them in Nágpúr is the description of them in Bengal, in Orissa, and in the Narbadá valley. In every case the grey "mudstones," the fine pale brown or greenish sandstones with their peculiar tesselated weathering, and the presence of huge transported blocks, generally rounded, are characteristic of the group.

Origin of boulder bed.

I doubt if we can yet clearly understand the origin of the 'boulder bed.' I suggested in 1856 that the boulders had been transported by ground ice, simply because that was the only way in which I could conceive the occurrence of huge rounded boulders in such very fine silt as forms the principal portion of the bed. The hypothesis is, I grant, improbable, and I should be delighted to abandon it if a better one can be suggested. But I cannot subscribe to my colleague Mr. Hughes's comparison of the boulder bed to the accumulations formed on the coasts of Penang.* In the first place there is no evidence whatever that the Tálchírs are a marine formation. Not a single marine fossil has been found throughout the great plant-bearing series from the Tálchírs to the Rájmaháls, and I cannot help thinking it most probable that all were river deposits; the Tálchírs might be lacustrine; but that their being supposed to be so would involve the hypothesis of so enormous a lake or series of lakes with similar deposits throughout. Still reading lake for sea, the difficulty appears to me just as great as ever. My friend, Mr. Hughes, suggests that the Tálchír boulders may be weathered round, not rolled. This possibly might account for their rounding in some cases, but certainly not in all. At Korhádí the boulders are not only rounded, but they have been brought from

* Mem. Geol. Surv., India, vol. v, p. 236. It is only proper to add that Mr. Hughes, when making this comparison, had only seen Tálchír rocks in places where they appeared to have been truly littoral deposits. He abandoned the idea, when subsequently he found Tálchír boulder beds where they could not have been littoral deposits.

a distance; they are of limestone and hard calcareous shale from the Vindhyans, often of considerable size, distinctly and unmistakably rolled, and all the rocks in the neighbourhood, including those on which the Tálchírs rest, are metamorphic. The difficulty remains. Any current or wave action which could move the boulders to the spot, would sweep away the fine mud in which they are imbedded.

General Portlock, President of the Geological Society in 1857,* while mentioning my view, expressed his preference for Mr. Mallet's theory of mud slips on a coast. This theory, which was proposed in order to explain the phenomena of the glacial drift and the grooves and scratches so prevalent on some of the rocks of Great Britain and Ireland, Northern Europe, and parts of America, was, that both the transport of blocks to great distances, together with gravel, sand, and mud, and the grooving of rock surfaces, may be effected by the slow movement of masses of detritus under water, and their "slippage" on the inclined rock surfaces of the sea bottom.† Mr. Mallet considered that the mere weight of loosely aggregated materials would suffice to carry them seaward even on a very low slope. Of course this view, if Mr. Mallet's premises be granted, would be applicable to deposits formed in lakes, and perhaps under peculiar circumstances in river valleys.

I cannot give in my adherence to the principle, notwithstanding its ingenuity. That slipping to some extent takes place, that fine materials at all events are moved seaward to a depth equal to the influence of tidal currents, is highly probable, if not certain; but that anything like the extensive and general movements of loose detritus suggested by Mr. Mallet is of common occurrence, has certainly not yet been proved, so far as I am aware. The evidence obtained by the

* Q. J. G. S., vol. xiii, p. cxxiii.

† Journal of the Geol. Soc. of Dublin, 1852, vol. v, pp. 121—129.

recent explorations of the deep seas, as to the presence of sand and small pebbles carried by the slow currents of the ocean, is a totally different matter, but so far as it has gone, it has only shown how sand and small pebbles can become mixed with oceanic mud. The phenomena which Mr. Mallet endeavoured to explain by his hypothesis of mud glaciers are, to this day, after far more investigation and long discussion, referred by most of the best living geologists to glacial action; and there appears to me one insuperable objection to the explanation of such rocks as the Tálchírs by 'mud glaciers' or 'slippage' in the fact that such an action of slipping in the manner insisted upon by Mr. Mallet, must necessarily destroy all trace of stratification. The boulder clay of North-Western Europe is certainly remarkable for the absence of stratification, but in the Tálchírs the bedding is well marked, and the form it assumes around the boulders is such as to show the effect of the pressure excited by such heavy bodies on the soft bed on which they were deposited, and their gradual envelopement by subsequent layers of the same fine silt.

[NOTE.—Since the preceding paragraphs were written, the Geological Survey have been fortunate enough to discover what had previously been sought for in vain-large masses of foreign or transported rocks imbedded in this fine Tálchír silt, the surface of which was polished as perfectly as marble by a lapidary; this polished surface being beautifully scored and furrowed in parallel and straight lines, precisely similar to the scoring, furrowing, and polishing which rocks carried down by glaciers, and ground ice, are so well known to exhibit. And further, the hard Vindhyan limestone, on which this Tálchír boulder-bed was laid, was also found to be scored in long parallel lines, wherever the upper surface was freshly exposed by the recent removal of the overlying rocks. After a little exposure, these scorings became obliterated by wearing off of the surface, or were covered and concealed by a thin deposit of re-crystallized calcareous matter on the surface, from water trickling over it, holding this calcareous matter in solution. This wonderful confirmation of Mr. W. Blanford's original supposition as to the mode in which this boulder-bed was, in places at least, accumulated, was not observed, I regret to say, until after Mr. Blanford had gone to the important work on which he is at present engaged with the boundary survey between Beluchistan and Persia, or I should have preferred that he should himself have had the opportunity of announcing the interesting discovery and modifying his statements.—T. OLDHAM, 1872.]

I cannot conclude without pointing out the remarkable coincidence of a boulder bed, which from the description* must somewhat resemble that of the Tálchír group, at the base of the Karoo beds of South Africa, in which beds several fossils are found, which are also found in different groups of the Indian plant-bearing series, especially *Glossopteris*, *Dicynodon* and *Palæozamia;* and suggesting that when the geology of Natal is better known, other members of them, besides the cretaceous formations, may be found to correspond to the rocks of India. The connexion was pointed out by Dr. Oldham many years ago, but appears to have escaped the attention of the geologists who have recently added so much to our knowledge of South African geology.

Damúdas, Kámthi Beds, and Panchets.—The beds which, in treating of the rocks of Nágpúr, I have called Kámthi beds, have, for some years past, been generally classed as Damúdas. This name was adopted by Mr. Hislop, and the question of the connexion of the beds with the typical Damúdas of Bengal was fully argued out by Mr. Hislop and by Sir Charles Bunbury, in the Quarterly Journal of the Geological Society for 1861, vol. xvii, pp. 341, 345, &c.

I certainly went to Nágpúr with the impression that not only the rocks were Damúdas, but that their identity with the Bengal beds had been established, on the best authority, by a comparison of the fossils. And even now I am not sure to what extent they should be removed from the series.

Mineral character of Kámthis.

In mineral character, however, all the Nágpúr, and the greater part of the Chándá, rocks, differ widely from the typical Damúdas of Bengal and the Narbadá valley. The latter consist of coarse soft felspathic sandstones, rarely conglomeritic, except towards the base, with brown, blue, and black shales,—the latter frequently highly carbonaceous and with beds of coal. Clay iron ore is rarely absent amongst them over any large area. The Kámthi

* Q. J. G. S., 1871, vol. xxvii, p. 58.

beds, on the other hand, are composed of grits, sometimes so hard as to be largely quarried for millstones, at other times soft and frequently ferruginous. These are often intersected by bands, in which the quartz, &c., are cemented together by peroxide of iron. The group also contains sandstones of various kinds, amongst which fine grained slightly micaceous beds, white in colour, with blotches and irregular streaks of red, are abundant; and the fine homogeneous argillaceous rock, which, for want of a better name, I have called a compact shale, yellow below the surface, but becoming deep red when exposed. The last bed is very characteristic.

No carbon.

So far as my examination extended, not a trace of carbon could be found; blue and black shales, coal, and clay ironstone are all wanting.

Such are the rocks around Nágpúr, where, however, only a few poor sections are exposed. At Bázárgáon there is a considerable thickness of conglomerate, the pebbles being mostly of white quartz, and the matrix a grit more or less compact, resting upon beds similar to those of Nágpúr. With this conglomerate fine red argillaceous sandstone is sparingly interstratified. There appears good reason to believe that these beds are a higher portion of the Kámthi group.

The beds of Mángli, which Mr. Hislop, for a long time, considered as identical with those of Kámthi, were by myself* classed as Panchets, chiefly on the evidence of the fossil *Estheria* found in them. This view was subsequently accepted by Mr. Hislop. After examining the rocks, however, I am compelled to return to Mr. Hislop's original opinion, as I can see no sound reason for separating the Mángli beds from those of Kámthi. The argillaceous sandstone, yellow and red, in which the fossils of Mángli occur, is precisely similar to that of Silewádá and other places near Nágpúr, and the associated sandstones present no difference of the smallest importance. They are very conglomeritic, and resemble closely the beds of Bázárgáon, which, as I have just shown, appear to

* M. G. S. I., vol. iii, p. 134.

be a little higher in position than the rocks of Kámthi, but still are an integral part of the same group.

We have thus the Kámthi beds hitherto looked upon as Damúdas, and the Mángli beds hitherto classed as Panchets, both belonging to the same group. To which of the two above-named formations are they to be referred, or do they belong to neither?

First as regards the Damúdas. The mineral character has been shown to be totally different. North-west of Nágpúr, in the Táwá valley, north of Bétúl,—north, in the Pench valley, near Chhindwárá,—north-east and east, in various localities from the neighbourhood of Jabalpúr to the Tributary Mehals of Katák,—and south, close to Chándá, Damúdas occur, always with precisely the same character. At Chándá moreover, these Damúda beds distinctly underlie rocks precisely similar to those of Kámthi, and the numerous borings which have been made for the purpose of proving the extent of the coal seam, as well as the survey of the country by Mr. Hughes, have shown that unconformity to some extent exists between the two groups. It is true that the Damúdas in Chándá very possibly represent only the lower sub-division or Barákar group of Bengal, and the Kámthi beds may replace the higher sub-divisions, the ironstone shales and Réniganj beds, but the Kámthis differ from the two last named in mineral character to even a greater extent than they do from the Barákar beds. So far as *mineral* character is concerned, therefore, it is impossible to assign the Kámthi beds to the Damúda formations.

Next as regards the Panchets.* I have very little hesitation in classing the red clays of Máledí,† south of the Chándá, containing *Cerato-*

* By Panchets I mean throughout this paper, except where upper Panchets are expressly mentioned, the beds called lower Panchets in my report on the Ráníganj coal-field. I am now convinced of the fact, which I suggested in that report (Memoirs Geological Survey, vol. iii, p. 30, note), that the name should be restricted to the lower division, the upper division being a well distinguished group.

† Memoirs, Geological Survey of India, Vol. I, p. 295. Quarterly Journal, Geological Society, Vol. XVII, p. 349; Vol. XX, pp. 117, 280.

dus and *Hyperodapedon*, with these beds; and I am inclined also to refer to them some other red clays found in the Pench valley, north of Chhindwárá, and in the Táwá valley, near Kesla, north of Bétúl.* The Máledí beds are also found in the Wardha river, near Porsa, between Chándá and Máledí, and in South-east Berar, west of Chándá. In all these instances, the clays are interstratified with soft white felspathic sandstone, and are remarkably similar to those found in the typical locality near Ráníganj, where, however, they are associated with very micaceous sandstone. In the Pench valley nodular limestone also occurs, but it is wanting to the south. There is certainly no resemblance in mineral character between the Kámthi beds and the Panchets in all these localities, which encircle the Nágpúr beds at a distance much as the Damúda localities do. There may be some slight resemblance between some of the beds in the "Upper Panchets" of Bengal and the Kámthi beds. But in cases where mineral character is called in as evidence of the identity of rocks in widely separated localities, something more than a slight resemblance is necessary. There may be a slight resemblance between the red clays of the Panchets or the red shales of the Panchet hill rocks and the red compact shales of Kámthi, and some of the sandstones are similar, but so are some of the Damúda sandstones; but still the Panchets are very unlike the Kámthis. On the whole, I consider that, judging from mineral character, the Kámthi beds must be distinguished from the Panchets.

The fossil evidence is more satisfactory. Sir C. Bunbury has identified the *Glossopteris Browniana*, Brogn., of Nágpúr, with that of the Damúda beds. Several other figures of Nágpúr fossil plants† are unmistakably of those species found also in the Ráníganj coal-field, and whether fig. 3, Pl. XI, of Sir C. Bunbury's paper, be that of *Vertebraria* according to McCoy and DeZigno or not, I do not think there can be a moment's doubt

* These were only seen during hurried visits for the purpose of examining the coal seams.

† Quarterly Journal, Geological Society, Vol. XVII, Plates VIII, IX, X, XI, and XII.

of its representing *Vertebraria indica* of Royle.* Now *Vertebraria indica* and *Glossopteris Browniana* are the typical plants of the Bengal Damúdas, and vastly more abundant than any other species except a *Phyllotheca*, which is probably also identical with the Nágpúr species. There is thus a very marked resemblance, if not absolute identity, between the Kámthi plants and those of typical Damúda beds.

On the other hand, the *Estheria* of Mángli has been, by Mr. Hislop (Jour. Bom. Br. R. A. S., vol. vi, p. 201,) and for a time by myself, considered identical with that of the Panchets. But the Panchet *Estheria* is not in a condition to allow of its microscopical structure being investigated an important point. Labyrinthodont reptiles have been found both at Mángli and in the Panchet beds of Bengal, but the genera are not the same. The known plants of the Panchet beds are apparently without exception distinct from those found near Nágpúr.

To sum up. There being an element of doubt about the *Estheria*, the only trustworthy connection of the Kámthi beds with any other known Indian group is with the Damúdas, and consists in both containing the same fossil plants. But although the species are, in some instances, the same, several are different, many of the most conspicuous forms of the Damúda beds appear to be wanting at Nágpúr† and others are rare. Until the vast mass of plant-bearing sandstones in Rewa and Sirgúja are better known, it is difficult to say what the ultimate classification of the different groups may be; but meantime it appears best to keep the Kámthis separate, both on economical and geological grounds, from both the Damúda and Panchet beds. It is far from improbable that they represent, in part at least, the Ráníganj group of

* I have perhaps had as many specimens of *Vertebraria* from the Indian coal-fields through my hands as any one living, and I cannot reconcile myself to the idea of its being a *Sphenophyllum* or any other fern. I have always looked upon *V. radiata* of Royle as merely a cross section of *V. indica*, and the plant itself as a hollow stem with radiating septa. Dr. Oldham and Sir C. Bunbury are probably correct in considering it a root.

† For instance, *Trizygia* and *Zeugophyllites*.

the Damúdas, or they may be intermediate in age between the Damúdas and Panchets.

Lameta or infratrappean.—This formation, as developed near Jabalpúr, is fairly represented in the Nágpúr country. The two sub-divisions, *a* and *b*, of Mr. J. G. Medlicott's memoir,* are represented respectively, *a* by the sandstone under Sítábaldí hill, and *b* by the limestone of Kelod, Chicholí, &c. The latter is, in both districts, the characteristic bed of the formation.

The re-examination of the Máhádevá rocks by Mr. H. B. Medlicott has led him to the conclusion that they are much older than the Lametas. To this I am quite disposed to agree, but I still think that there may be a connexion between the Lametas and the Bágh beds as explained in my description of the latter.† It should, however, be remembered that the marked local unconformity between the traps and Bágh beds does not appear, near Nágpúr at least, to exist between the former and the Lametas.

I have, in the preceding pages, used the term infratrappean in preference to Lameta, because it better expresses the close connexion between these beds and the traps. Some of the intertrappeans seen on the Seoni table-land and in the trap country west of Nágpúr, consist of precisely the same grey limestone with cherty masses which form the most persistent and characteristic rock of the underlying group. As a rule, the infratrappeans, or Lametas, are gritty, while the intertrappean beds are not, but there are exceptions, and Mr. Hislop's‡ view of the two being parts of the same group appears to be correct.

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* Memoirs of Geological Survey of India, Vol. II, p. 197.

† Memoirs of Geological Survey of India, Vol. VI, p. 54.

‡ Quarterly Journal, Geological Society, Vol. XVI, p. 159.

MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

The GEOLOGY OF MOUNT SÍRBAN, *in the Upper Punjáb, by* W. WAAGEN, Ph.D., *and* A. B. WYNNE, F. G. S., *Geological Survey of India.*

Mount Sírban (Seer Bun), rising close to the southward of Abbotabád station, is one of the most lofty of the Hazára* hills: a portion of those which form the outworks of the north-western Himalaya bordering the Upper Punjâb.

The latest, if not the only, published reference to the geology of this locality of which we are aware occurs in Dr. Albert Verchère's paper read before the Asiatic Society in Calcutta on "Kashmir, the Western Himalaya, and the Afghan Mountains,"† communicated in 1866-67. In this paper Dr. Verchère gives a rough section with a description of the northern [*i. e.,* north-eastern] end of the mountain, stating that he recognised carboniferous limestone resting upon volcanic rocks. The beds above these he referred in a general way to the jurassic formation, and the highest strata on the northern side of the mountain to the nummulitic limestone: the detailed descriptions of the rocks and construction of the section which he gives are, however, so inadequate to represent the facts as to render their recapitulation undesirable.

At first sight the mountain looks very similar to others in the vicinity, formed chiefly of limestone and shale, but presents a strong con-

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* Spelled Huzaruh by thè Revenue Survey.

† Journ. As. Soc., Beng., Vol. XXXVI, 1867, pt. ii, pp. 29, &c.

trast to the slate hills of softer and more monotonous outline, which rise immediately from its north-western slope. It has an elevation of 6,243 feet, with an elongated oval base, is entirely isolated from the surrounding hills by deep narrow glens, and is penetrated by steep sided ravines radiating from the summit. Its form is massive, and its outline heavy, presenting convex curves to the northward, suddenly interrupted by precipices, which, facing to the southward, extend along its crest and send rugged broken spurs into the valley below.

The structure of the mountain is interesting, affording, as it does, an epitome of much of the geology of the North-West Frontier of British India, there being, indeed, not many members of the series, as at present known, absent, and those unrepresented being chiefly the oldest crystalline and the newer divisions of the tertiary rocks.

Different portions of the ground afford sections differing not only in their comprehensiveness, but also in there being strata present in some which do not recognisably recur in others. A great longitudinal fault traverses the whole mountain, besides smaller dislocations in other directions, while one prominent unconformity, another less perfectly apparent, and possibly yet others latent, go far to explain the want of uniformity in the sections from which the following succession has been deduced:—

6.—NUMMULITIC ...	Thick limestones with some shales—fossils in places.
5.—CRETACEOUS ...	Thin-bedded limestones—without fossils apparently. Impure ferruginous sandy limestone, weathering rusty—fossils.
4.—JURASSIC	Black Spiti shales.
	Unconformity.
3.—TRIASSIC	Thin-bedded limestone and slaty shales. Dolomite, limestone; fossiliferous (*Megalodon* and other) beds.
2.—BELOW THE TRIAS ...	Hæmatite, dolomite, quartzite, sandstone and breccia.
	Unconformity.
1.—SEMI-CRYSTALLINE ...	Attock (?) slate.

The whole character of the divisions just mentioned admits of no doubt that the strata exposed at Sírban possess the Alpine facies well

developed in the formations of the great north-western Himalayan region. It is, therefore, in this direction that we should seek for a correlation of the Sírban strata with the latter, but unfortunately the most detailed information relating to this Himalayan region is that regarding the Spiti district, which is separated from Hazára by the whole of Cashmere, with all its accumulations of crystalline and eruptive rocks. Besides, Spiti lies on the north-eastern side and Hazára to the south-west of the lofty crystalline range, continuing from the Pír Punjâl through the Kyjnâg, in Cashmere, towards the north-west.

Notwithstanding the distance and difference in orographical position, the affinity between the Hazára and Spiti rocks is in certain points even greater than one would have expected, and Dr. Stoliczka's Memoirs on Spiti and Western Tibet* in many respects afford guidance in studying the formations of the Hazára mountains.

1. Attock Slates.—These are apparently the upper portion of the slate series, which is in other places metamorphosed into talcose schists, and presents a complex transition into the porphyritic syenite of the mountains to the northward, at a distance of fifteen or sixteen miles from Sírban. The series varies greatly; is, so far as hitherto searched, quite unfossiliferous, and is most accessible at Attock on the Grand Trunk Road. At Attock, and in other places, it includes massive zones of limestone, generally of dark colour, but sometimes white and flaggy, and in texture either resembling lithographic limestone, or horny, or finely saccharine, as if metamorphosed.

At Sírban the slates are usually dark or black, alternated with greenish-gray or olive sandstones, and have sometimes a deep liver colour. Some limestones associated with them in an outlying hill near Dhumtour may belong to such zones as abovementioned. The cleavage

* Memoirs, Geological Survey of India, Vol. V, p. 1: *ibid*, Vol. V, p. 337.

is not always perfectly developed in the immediate neighbourhood, but at no great distance, these slates might very possibly afford tolerable roofing material if suitable excavations were made for the purpose of proving them. The beds dip at high angles with a general strike to the north-east.

No dykes, nor igneous rocks, have been observed associated with this series about Sírban. The age of these slates is as yet unknown, no organic remains having been discovered; but judging from analogy with other parts of the Himalaya, their transition to the northward into micaceous slates, talcose schists, and porphyritic syenite, would point to their connexion more or less with the crystalline series. A slate series in Spiti is mentioned by Dr. Stoliczka, of bluish colour and often silky aspect, in which are interstratified greenish silicious sandstones. To this he attributes a silurian age; and probably, if there were more points for comparison, the Attock slates would prove the same. The thickness of the series must be immense.

Crystalline rocks (quartzites and mica slates) were known to exist in the north of Hazára by Dr. Fleming—see Rep. on the geol. structure of the Salt Range, Jour. Asiat. Soc., Beng., vol. xxii, 1853, p. 354.

The same fact is referred to by Dr. Verchère in his paper on the geology of Kashmir, the Western Himalaya and Afghan Mountains—Jour. Asiat. Soc., Beng., 1866, pt. II, p. 109, and foot note from Jour. Agri.-Hort. Soc., India, vol. xiii.

With regard to the possibility of the Attock slates being silurian, or associated with rocks of this age in their extension westward from Sírban, it is on record that Dr. Falconer found lower silurian fossils derived from the Khyber hills in the bed of the Cabul river, and hence in the region most probably occupied by the continuation of the slates beyond Attock—see papers on the Carb. rocks of Cashmere, by Captain Godwin-Austen, Quar. Jour. Geol. Soc., Lond., vol. xxii, 1866, p. 29.

2. Below the Trias.—This group affords the mixed assemblage of rocks which have received the names "Cornean," "Volcanic," &c., &c., from Dr. Verchère. It rests with total unconformity upon the slates, the basal rock being, in places, a red argillaceous breccia full of large fragments from the underlying beds.

The group presents two principal divisions, the lower one consisting chiefly of red sandstones, red shales, and red quartzitic dolomites, the upper one composed of dolomites only, of lighter colour, often highly silicious, and of very considerable thickness.

A third group, composed of hæmatitic rocks, quartz breccias, sandstones and shales, may belong either to this or to the succeeding group, and has been included in this division mainly on account of its marked difference from the limestone series above.

The red sandstones and shales have a very characteristic aspect, and remind the observer strongly of the dull red sandstones far below the carboniferous formation, and immediately overlying the bright scarlet saline marl of the salt range: there, however, the associated quartzose dolomites are absent, and the analogy ceases.

There is no portion of the Spiti series, according to Dr. Stoliczka, which would bear comparison with the red sandstones of Sírban.

These beds possess also a strong resemblance to the 'Werfener Schichten' or the 'Bunter Sandstein' of the Alps, but it would be more than hazardous to attempt to relegate them to that distant formation.

The upper division of the beds 'Below the trias'–the dolomites–are certainly, from their clearly observed superposition, newer than the red sandstones, &c. Fossils have not as yet been detected in them, so that their precise geological position is uncertain, and they might be placed either in the carboniferous or lower trias formations. It is, therefore, justifiable to avoid a closer designation of the whole group indicating only its place underneath the true triassic rocks.

That the development of the group is not everywhere the same will be seen by reference to the subjoined sections, pink, purple and white quartzitic sandstones of Vindhyan aspect occurring on the same horizon at Shah ke Vandi.

The hæmatitic series, the difficulty of assigning a place to which has been already mentioned, occupies a large area, its detritus forming nearly all the cultivable ground on the higher portions of the mountain, and its impermeability enabling the residents to collect the rain water in tanks so as to supplement the supply afforded by the singularly few springs which exist except in the vicinity of the nummulitic limestones.*

3. THE TRIASSIC SERIES is formed of dark or black, or gray, distinctly bedded limestone, with thick zones of massive dolomite, some portions of which contain numerous laminæ of opaque white quartz. Near Abbotabád the limestones are extensively quarried for building purposes, and are often crowded with indistinct gastropoda and bivalves of triassic forms, among the latter of which is the flat shell called by Dr. Verchère an *Athyris*. Where the series is complete, dolomites form the lowest beds, above which are thin-bedded limestones with fossils. The dolomites, however, are absent in many places, and the

* On the line of the main fault close to Shah ke Vandi several springs occur, and one of them of unusual size after rain was observed to pour forth a large rivulet of muddy water, the course of the stream close to which it is situated being almost entirely dry everywhere above it. Other large and picturesquely located springs occur in the neighbourhood of Dhumtour. Portions of the hæmatitic beds are so rich in iron as to become an ore, which would possibly have been utilised but for the almost utter absence of anything in the shape of a tree around or upon the whole mountain.

From its tendency to weather down and descend the hill slopes, its exact horizon is often difficult to see. It would appear from sections 1, 5, and 6 that its proper place is at the junction between the infra-triassic and triassic rocks, but in section 3, it seems to occur rather as a member of the Trias itself, unless some obscure dislocation or the occurrence of a newer zone takes place. With regard to the whole group below the Trias, we have found no sufficient reason to suppose its breccias or other beds traceable to volcanic action, as has perhaps been supposed by Dr. Verchère: its thickness at different exposures ranges from one hundred to about one thousand feet.

limestones with *Megalodon* follow immediately above the infra-triassic group. These thin-bedded limestones are succeeded by quartzites and dolomites of very considerable thickness, again overlaid, in certain situations, by thin-bedded limestones and slaty shales, which, on account of their containing a different fauna, we have divided from the rest. The group, therefore, presents two divisions, a lower one, consisting of limestones and dolomites with *Megalodon* and *Dicerocardium*, and a superior one, consisting of slaty shales and limestones with *Nerineæ*. In the lower division, at the apparent base of the whole triassic series, and immediately resting upon the hæmatite, which we have provisionally included in the group beneath, is a strong bed of limestone thickly studded with large sections of *Megalodon*, *Dicerocardium*, *Chemnitzia*, and *Gervillia*. The same or another zone,* also associated with hæmatitic strata, contains similar fossils in a situation on the northern slope of the mountain, which, if undisturbed, would occupy a place high up in the formation. From the fossil sections exposed on weathered surfaces of these beds the accompanying outlines were copied (fig. 1), it being utterly impossible to get the impacted specimens out of the hard rock, from which they do not separate. In other beds occur different organic remains, principally uncharacteristic forms of bivalves and gastropods, with *Rhynchonellæ* and very scarce and badly preserved *Terebratulæ*, possessing but little stratigraphical value.

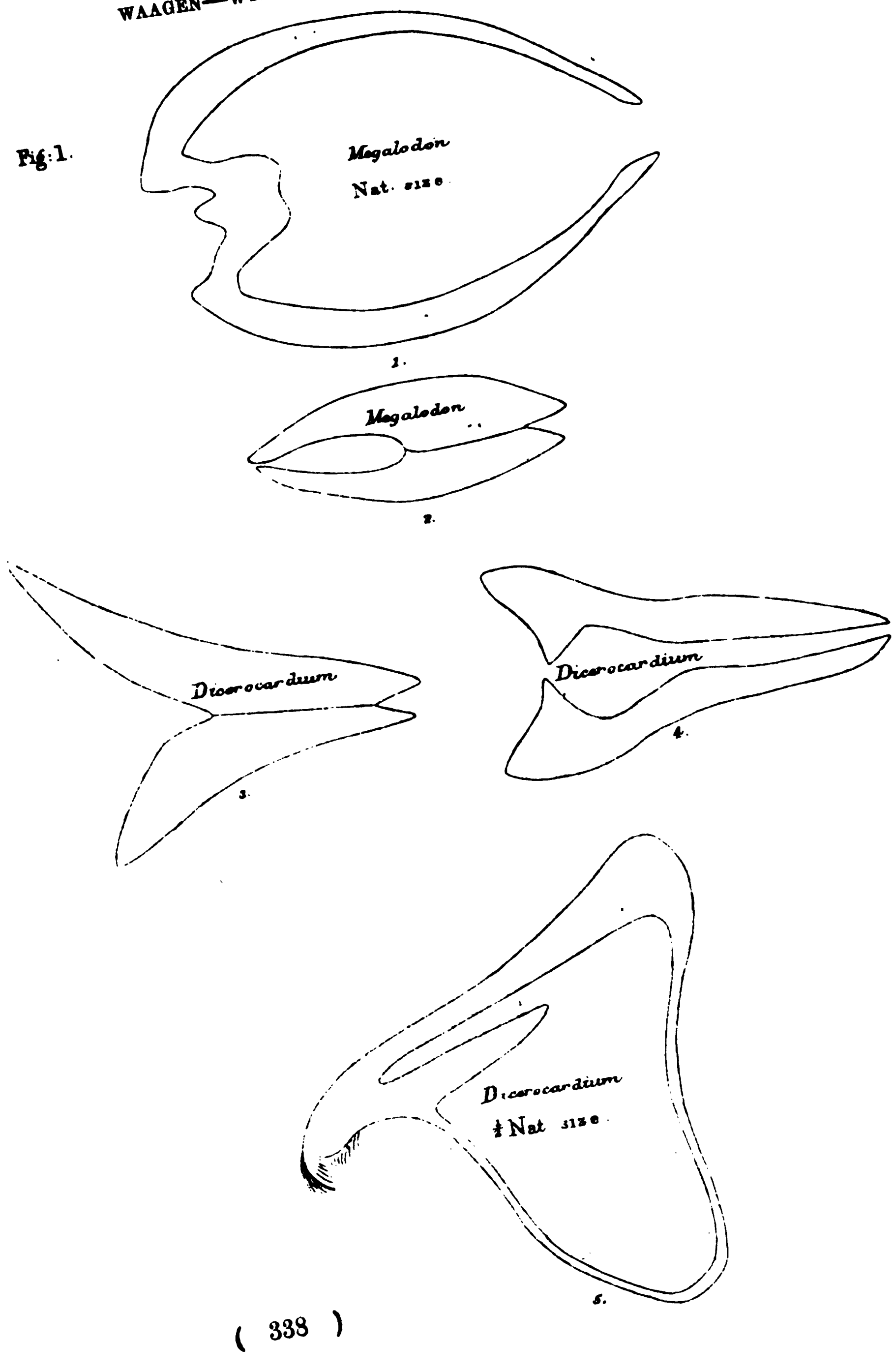
Were not the *Megalodon* and *Dicerocardium* present, we would have found it difficult even to ascertain the triassic age of the group.

These genera are characteristic of the upper trias in Europe, and in order to ascertain if they are the same here, we have to refer to the geology of Spiti.

Above the limestones there with *Amm. Studeri, &c.*, representing with great probability the Muschelkalk of Europe, Dr. Stoliczka

* Which it is could not be easily made out, owing, probably, to obscure dislocation, very possibly allowing the lower beds to be repeated.

Fig: 1.


Megalodon
Nat. size
1.
Megalodon
2.
Dicerocardium
3.
Dicerocardium
4.
Dicerocardium
½ Nat size
5.

distinguishes a series of black bituminous dolomitic limestones of 700 to 1,000 feet in thickness, his 'Para limestone,' in which he found *Megalodon triqueter*, *Dicerocardium Himalayense*, several species of *Chemnitzia* of the character of those from the "Esino dolomite," and *Neoschizodus*. Though it is true that we are unable to determine the species, still the association of *Megalodon*, *Dicerocardium*, and *Chemnitzia* would seem to indicate that our lower triassic division is the analogue of the 'Para limestone,' and thus equivalent to the lower part of the upper trias of the Alps.

The upper division of the triassic formation could only be distinguished at a few localities by the character of the rocks, or by the appearance of certain fossils. It is best seen in the Sulhud valley or pass, on the Abbotabád road, about a mile and a half below Sulhud. At this locality, about one hundred feet of olive-coloured sandy slaty shale, in places very similar to real slate, overlies the dolomites of the lower division. These pass up by soft greenish sandy shales into yellow and brown dolomitic sandstones without fossils, and are succeeded by thin-bedded, light-coloured gray limestones, with intercalated sandy beds having a total thickness of about one hundred feet.

On the weathered surfaces of these limestones numerous fossils are to be observed, the genera, however, though indicating newer beds, present species generally of no great geological value. They include *Nerineæ*, *Neritopsis*, *Astarte*, *Opis*, *Nuculæ*, *Ledæ*, and *Ostreæ*.

Similar limestones, but without the underlying shales, are exposed on the south-eastern side of the mountain above Banduh; they contain numerous *Nerineæ*, some of which are in good preservation, but very difficult to extract. It is probable that exposures of these limestones continue hence towards Dhumtour, but only a very close examination of the mountain would prove their existence, as the occurrence of the fossils, and not the appearance of the rock, here distinguishes the group.

The reasons which led us to unite these beds with the triassic formation are, first, the unconformity above, distinctly separating them from the jurassic rocks, and also the analogies which they present with a certain division of the Spiti beds: the *Nerineæ* here first appearing in the ascending section, which is also the case with regard to the 'lower Tagling' limestone of Stoliczka, lying next above the "Para limestone," to which we have relegated our lower division.

This leads us to consider the *Nerineæ* beds of Mount Sírban as the probable representatives of the 'Tagling limestone' of Spiti.

The variations in the sections of the whole triassic group are very great. We have already mentioned that the dolomites at the base of it are often absent. The slaty shales, too, of the upper sub-division have only been observed in one locality, although there of more than 100 feet in thickness. The dolomites at the junction of the upper and lower divisions are not less changeable, being sometimes thick-bedded and silicious, sometimes thin-bedded and crystalline, or even replaced by gray limestones. It is possible that this changeability may be in many cases only apparent and be accounted for by unconformity or overlap, while the whole group may rest unconformably upon that beneath it, but in the absence of conclusive evidence this is not asserted. The group forms a massive covering, sheeting the north-west slopes of the mountain, occupying the position assigned to the nummulitic limestone in Dr. Verchère's sketch section, and separated by a fault, which coincides with the Sulhud pass or valley from the slate mountains opposite. The thickness of the triassic series may be from 1,000 to 1,200 feet.

4. Jurassic.—To represent this series at Sírban we have only the jet black shaly clay beds, well known in Himalayan Geology as "Spiti shales." Though much reduced in thickness, they are of great importance as a help to recognise the stratigraphical relations in this country, where uniform gray limestones, from the nummulitic down to the infra-triassic, compose whole mountains of 10,000 feet in altitude. Still the

easily abraded nature of these black shales, and the circumstance that they occur, as a rule, close to dislocations, in the least accessible parts of the mountain, or where slippage and breaking down *en masse* of the nummulitic limestone tend to conceal them, or where a combination of these causes occurs, places much obscurity in the way of ascertaining the definite limits of the formation, the position of which in the series would even be difficult to decide were it not for its organic remains, which leave no doubt whatever as to its age. The Sírban spiti shales are not so rich in fossils as those of Changligully, referred to in a former notice in these records.* We have found, however, *Perisphinctes frequens*, a fragment of a *Belemnite*, *Inoceramus*, and *Corbula*.

The unconformity of these shales upon the older rocks is most easily to be observed on the long spur south by west from the summit of Sírban, the surfaces of the underlying triassic limestones being eroded, pierced by the holes of boring molluscs, and successively overlapped by the Spiti shales.

On the north-east end of the mountain near Dhumtour these shales have not been observed, the cretaceous beds appearing to follow immediately upon the triassic limestone. The thickness of the group may average from 30 to 50 feet, though the wasting down of their black débris would make it appear much thicker.

5. Cretaceous.—Towards the upper part, the foregoing group becomes gradually more calcareous and sandy, and a few beds of gray calcareous sandstone supervene. Immediately upon these rests a strong bed of similar petrographical character, but much harder, weathering of a rusty colour, and commonly crowded with fossils of cretaceous genera and species. These rusty beds form a zone from 10 to 20 feet in thickness, and have been observed at several points, the orange colour of the band enabling it to be followed by the eye even at considerable distances.

* *Vide* Records, Geological Survey of India, Vol. V, pt. 1, p. 15, 1872.

The fossils are mostly coated with iron oxide, and project slightly from the weathered surface of the rock, but these portions only could be obtained. They are chiefly cephalopods, with a few gastropods; one *Inoceramus* has also been collected. The ammonites found belong nearly all to the exclusively cretaceous groups of the *Cristati* and *Inflati;* besides these several species of *Ancyloceras, Anisoceras,* and *Baculites* appear. The *Belemnites* are numerous and of rather extraordinary size for their geological age. The impression which the whole of the fossils leaves upon the observer is that of a 'Gault' fauna.

Above this fossiliferous zone comes a group of thin-bedded limestones, of gray colour, with even bedding planes, but apparently destitute of organic remains; it may belong either to the cretaceous or the nummulitic rocks, but from its absence in other places at the base of the latter formation, it is considered more likely to be a member of the former.

Nothing in the geological literature of the Himalayas with which we are acquainted would have led us to anticipate the occurrence of any cretaceous zone except "Rudista limestone," yet we were not taken by surprise, but rather expected to find another representative of the cretaceous formation, having already observed along the frontier and in other parts of the Punjâb an equivalent of the Neocomien group. The latter is, however, apparently not represented at Sírban, while the fossiliferous zone and overlying limestones may be equivalent to the middle and upper sub-divisions of the cretaceous series. Turning again to the memoir upon Spiti, we find the following succession given :—

Chikkim shales Chikkim limestone	} Cretaceous.
Gieumal sandstone Spiti shales	} Jurassic.

The Chikkim limestone may with some probability be upon the same horizon as the thin-bedded cretaceous limestones of Sírban, but

whether the Gieumal sandstone or any part of it corresponds to the fossiliferous zone, is, on the evidence before us, impossible to decide.

The unfossiliferous limestone group presents all the appearance of passing upwards into the nummulitic formation, and may have a thickness of from 50 to 70 feet.

6. THE NUMMULITIC FORMATION, as usual among the border hills of the Punjâb, is chiefly composed of massive gray and blackish limestone, here alternating, less than it generally does, with thick zones of dark coloured shale. Its thickness is very great, its stratification violently contorted, and it possesses the same features commonly observable, of profound gorges and ravines excavated in it, high cliffs formed, and, upon slopes, of great masses having subsided so as to produce complications of slippage often exceeding in amount the throw of genuine faults.

Its fossils are not well preserved, and with some exceptions the beds appear to be pervaded by swarms of small *Nummulinæ* and other Foraminifera, casts of gastropods and other shells, more or less imperfect; occurring here and there as well. In one or two places a few beds of soft white sandstone form its base.

With a view to clearer illustration of the structure of the mountain, the following rough sketch sections (not drawn to scale) are extracted from our note books:—

Fig: 2.

1. Section near Abbotabád, at Shah ke Vandi. (Fig. 2).

11.	Nummulitic limestone.	
10.	Dolomite	Trias.
9.	Breccia	Trias.
8.	Red sandstone shales and breccia below the Trias.	
7.	Compact black limestone, Gastropods, *Rhynchonellæ*, &c... Strong *Megalodon* bed at base	Trias.
6.	Breccia limestone fragments—Trias—(apparently not continuous).	
5.	Brecciated hæmatite	Below the Trias.
4.	Compact white clay	Below the Trias.
3.	Red shales	Below the Trias.
2.	Yellow dolomite and saccharine magnesian limestone ...	Below the Trias.
1.	Pink, purple, and whitish quartzitic sandstone	Below the Trias.

NOTE.—This is pretty nearly the same section as that so elaborately, but incorrectly, given by Dr. Verchère. His cornean rock is probably the silicious and dolomitic triassic breccia, which may also include the white quartzite of his next division. His "chocolate coloured claystone" is perhaps the hæmatite, associated with which are light colored clays, not, however, apparently chloritic. Which of the rocks those are having a 'felspathose' composition according to him, it is difficult even to guess, and none of the deposits suggest either a volcanic origin or composition.

2. Section behind, *i. e.*, eastward of the Travellers' Bungalow.

(*Dip to west by north*, 35.°)

5.	Dark fossiliferous limestone—	Trias.
4.	Sandstone and calcareous bands—obscure plants ...	Below the Trias.
3.	White, shaly, and variegated beds	Below the Trias.
2.	Quartzose sandstones	Below the Trias.
1.	Hæmatite, probably brought into junction by dislocation...	Below the Trias.

3. Section near the entrance to the station of Abbotabád from the direction of Sulhud. On the slope of the mountain:—

(*Dip about north-west*, 35° *and less*).

6.	Strong limestone, with *Megalodon*, *Dicerocardium*, &c., &c.	Trias ?
5.	Shaly and argillaceous variegated hæmatitic beds—Fucoids and other obscure plants	Trias ?
4.	Flaggy, red sandy beds and lumpy limestones ...	Trias ?
3.	Quartz breccia	Trias ?
2.	Cherty dolomite with quartz layers (possible dislocation)...	Trias ?
1.	Well stratified limestones—fossils. *Pecten*, *Lima*, and other bivalves and gastropods	Trias ?

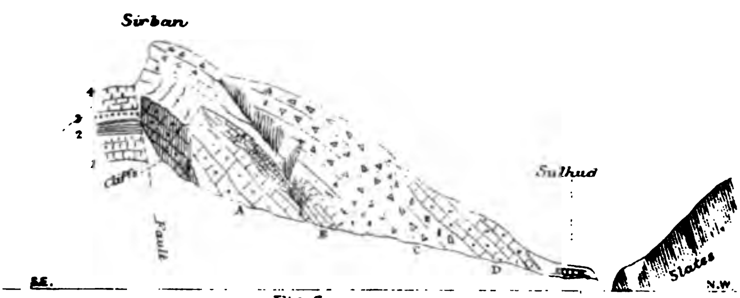


Fig. 3.

4. Section in the ravine from near Sulhud to the summit of Sírban :—(Fig. 3).

D—Dolomite	Trias.
C—Thick quartzites and breccia	
B—Thin-bedded limestone with some fossils...	
A—Dolomites	
Fault.	
4.—Nummulitic limestone	Nummulitic.
3.—Cretaceous zone (fossils)	Cretaceous.
2.—Spiti shales—fossils	Jurassic.
1.—Limestones	Triassic.

5. Section at south-western end of mountain :—

6.—Thick dolomite and breccia (perhaps A of Section 4) ...	Below the Trias.
5.—Dull soft red sandstone.	
4.—Red shale with green bands	
3.—Red quartzose dolomite	
2.—Red argillaceous breccia with slate fragments	
Unconformity.	
1.—Black and dark colored slates and sandstones—	Attock slate.

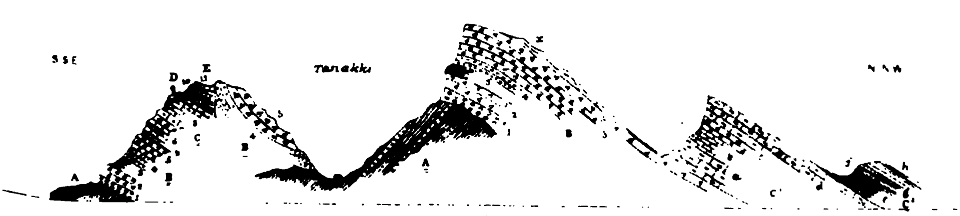


Fig. 4.

6. Section through the south-west end of the mountain: direction south-south-east to north-north-west:—(Fig. 4).

E—Cretaceous.
D—Jura.
C—Trias; (C[1] Para limestone. C[2] Tagling limestone).
B—Infra-triassic.
A—Slate series.

11.—Thin-bedded limestone, unfossiliferous	Cretaceous.
10.—Sandy, rusty limestone, numerous fossils, principally Cephalopoda	
9.—Spiti shales	Jura.

(Unconformity on eroded surfaces of next series).

8.—Dolomites and limestones, thin-bedded, fossils in places ...	Trias.
7.—Thick-bedded limestones	
6.—Thin-bedded limestone, with numerous fossils of indefinite character—Gastropods, *Pectens*, *Rhynchonellæ*; at base, bed with *Megalodon*.	
X.—Bed of hæmatitic silicious breccia very variable in thickness, often entirely disappearing, in some places associated with white sandstone and red clays.	
5.—Red and yellowish cherty quartzose dolomite	Below the Trias.
4.—Soft dull red sandstones	
3.—Red shales	
2.—Red quartzitic dolomite	
1.—Red conglomeratic breccia, with subangular slate boulders...	

Unconformity.

A—Attock slates—soft, slightly cleaved, with many soft gray micaceous sandstones intercalated.	Slate series.

This is the succession of strata on the spur south of Tannaki. Along the crest of this spur runs a fault, which brings the dull red sandstone of the infra-triassic series into contact with the cretaceous formation. The sandstones dip down the north-western hill slope covered by cherty dolomites, and come out again a little above Tannaki, resting upon slates.

The next ascent shows the same succession, but the slates reach here far up the hill side. The different divisions of the infra-triassic

series form here a lofty precipice, which is visible from a great distance, and well exhibits the red colour of the dull-red sandstone and red shales. On the northern slope, where the layers dip down towards the valley of Sulhud, a thin sheeting of clays, fragments of white sandstones, and hæmatitic silicious breccia covers the bedding surface, but these rocks cannot be observed in situ under the succeeding triassic dolomites.

7. On the north-western end of the section, the succession of beds is a little different from that on the southern spur. It is as follows :—

h.—Thin bedded limestones with sandy layers and numerous fossils. Among others *Nerineæ, Neritopsis, Astarte, Opis, Nucula, Leda, Ostrea;* not of determinable species; thickness nearly 100 feet.	Trias (Tagling limestone).
g.—Yellow and brownish dolomitic sandstone without fossils, 10 feet.	
f.—Greenish sandy shale	
e.—Olive sandy slaty shale, about 100 feet	
d.—Thick-bedded dolomites	Trias (Para limestone).
c.—Dolomite with chert	
b.—Thin-bedded limestone with fossils—*Pecten, &c.* ...	
a.—Thick dolomites	
5.—Red cherty quartzose dolomites	Below the Trias.

8. Section over Banduh, south-east side of mountain.

(Bedding nearly horizontal and rolling).

γ	5	Nummulitic limestone	Nummulitic.
		Soft light-colored sandstone, a few beds only ...	

(Dislocation).

2.—Dolomite	Trias ?

(Dislocation).

β	5.—Nummulitic limestone	Nummulitic.
	4.—Cretaceous sandy limestone (fossils)...	Cretaceous.
	3. Spiti shales	Jura.
	3. Limestones, with *Nerinæa*	'Tagling limestone.'

(Dislocation).

α	5.—Nummulitic limestone—thick.	
	4.—Cretaceous beds as above.	
	3.—Jurassic zone, dying out or concealed.	
	2.—Triassic limestones, &c., as before.	
	1.—Red sandstones, &c.	Below the Trias.

The series marked α is much disturbed and confused by slippage of the nummulitic and some of the underlying beds downwards on the hill slopes. It is interrupted by a fracture beyond which the jurassic and cretaceous beds β again underlie the nummulitic rocks. Another disturbance allows a small quantity of dolomite just to reach the surface, and then some soft white sandstone occurs at the base of the nummulitic limestone γ which forms this portion of the crest of the hill.

9. Section near Dhumtour:—

6.—Nummulitic...	Nummulitic.
5.—Very markedly-bedded limestone (unfossiliferous) ...	Cretaceous.
4.—Cretaceous zone	
3.—Thin-bedded limestone, (fossils)	Trias.
2.—Traces of red sandstone	Below the Trias.
(*Unconformity*).	
1.—Red and black slates and a few sandstone bands ...	Attock slates.

The Spiti shales have not been observed in this neighbourhood; they may be either absent or concealed.

In reviewing the facts mentioned in the foregoing pages several interesting conclusions may be drawn. It is of special interest that Sírban, being a locality south-west of the first great crystalline axis of the Himalaya—of which region the palæontological geology is as yet little known—affords a means of comparing the formations on both sides of the above-mentioned axis.

In order to do this, it will be useful to abstract from the papers of Dr. Stoliczka a tabular resumé of the Himalayan formations placed in comparison with those of Sírban:—

Sirban.		Stoliczka: Spiti.	
	Nummulitic.	... ...	
Cretaceous ...	Unfossiliferous limestone ...	Chikkim shale	*Cretaceous.*
		Chikkim limestone	
	Fossiliferous zone	... ... ? ...	
... ...	... ?	Gieumal sandstone	*Jurassic.*
Jurassic ...	Spiti shales...	Spiti shales	
	Unconformity.		
Triassic ...	Thin-bedded limestone and slaty shale	Tagling limestone	*Triassic.*
	Dolomite and *Megalodon* limestone	Para limestone	
Below the Trias...	Silicious Dolomite	Lilang series ? ?	
	Red sandstone and shale ...	... ... ? ...	
	Unconformity.		
		Kuling series ?	*Carboniferous.*
		Muth series ?	*? Silurian.*
Slate series ...	Attock Slates	Babeh series ?	

It is apparent that though there is a general similarity, the two regions on opposite sides of the crystalline axis show several points of difference, though not so great as to deprive us of hope that they may be brought into closer accordance by subsequent researches. At present the main differences are rendered greater by the occurrence of marked unconformities in one region unrecorded in the other.

It seems that the area round Sírban was subjected to great and continuous disturbance during the long period from the close of the slate age up to that of the jurassics, followed by a time of tranquillity, during which the Spiti shales, the cretaceous and the nummulitic formations, were deposited.

It would be highly interesting, if possible, to find out whether the periods of disturbance coincide with the eruptions of the volcanic rocks known to exist in the interior of Cashmere.

In concluding this brief notice of the locality, we append a sketch map taken from the Revenue Survey of Hazára (Huzaruh) in order to show the distribution of the different formations, mentioning at the same time that as our object was to make out the succession when upon the ground, rather than to survey all the minute details, we have not sought to map the boundaries with absolute accuracy as yet. The discrepancies likely to exist are, however, so slight that this consideration has not prevented us from indicating the general extent and positions of the series to which the rocks have been referred.

MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

On the occurrence of AMMONITES, *associated with* CERATITES, *and* GONIATITES *in the Carboniferous deposits of the* SALT RANGE, *by* WILLIAM WAAGEN, PH.D., *Geological Survey of India.*

During my late geological tour in the North-Western Panjáb and the Frontier Districts, my principal duty consisted in determining the relations of the rocks, there represented, with European formations. Such studies can only be based upon palæontological investigation, which will alone be able to solve questions about the relative ages of the rocks in distant countries. Thus, it was necessary for me to direct my principal attention towards collecting fossils according to their different stratigraphical horizons, and the result has been that several remarkable and unexpected palæontological facts have come to light, besides the general geological results.

One of the former is the discovery of specimens of three well known genera of Cephalopodous Mollusks, *Goniatites, Ceratites*, and *Ammonites*, all together in a limestone bed of about one foot and a half in thickness, in the lower half of the upper division of the (?) carboniferous formation in the society of unmistakable *Producti, Athyris*, etc.

The locality whence I extracted those fossils with my own hands out of the rock, is near Jabi north of Shahpoor, on the southern slope of the Salt Range. The rocks at this locality are, however, not well adapted for tracing out an extensive section, because the ground is greatly broken up and faulted in every direction. Ascending the mountain

range north of Jabi, by the road which leads round the well of the village, one finds, after having crossed a little plateau, a well bedded series of thin limestone bands, intercalated with shaly marls, the whole about 20—25 feet in thickness, and in the upper part of this series one calcareous band principally is rich in fossils. Brachiopods occur plentifully in the whole series, but Cephalopoda are only found in this thin bed.

Some of the species, which I can easily determine from Davidson's 'Brachiopods of the Salt Range,' are the following:—

Terebratula Himalayensis, Dav.
Retzia radialis, Phill.
Athyris Roissyi, L'Ev.
„ *subtilita*, Hall.
Spiriferina octoplicata, Sow.
Streptorhynchus crenistria, Phill.
„ *pectiniformis*, Dav.
Productus costatus, Sow.
„ *Humboldtii*, Orb.
„ *longispinus*, Sow.
Strophalosia Morrisiana, King.

Together with these Brachiopods, and beyond any doubt coming out of the same beds, I collected several specimens of three Cephalopods, which deserve a more detailed notice. They are—

Phylloceras Oldhami, Waagen, n. sp.
Ceratites carbonarius, Waagen, n. sp.
Goniatites primas, Waagen, n. sp.

Above this thin-bedded calcareous series, with the fossils just mentioned, follows, at Jabi, a brown sandy dolomitic rock, rather thick-bedded, in which

Dentalium Herculeum, Koninck, and
Bellerophon Jonesianum, Koninck,

are found in abundance. The series with these two species includes, all along the Salt Range, the highest beds in which *Producti* and *Athyris* sometimes occur. Above them follow everywhere limestones and green marls, with the *Ceratites* described by Koninck; *Bellerophon*, however, goes higher up into the Ceratite beds.

It is not without some doubt that I refer the thin-bedded marly calcareous series with Cephalopods to the carboniferous period, though it seems certain that *Athyris Roissyi*, L'Ev., *Athyris subtilita*, Hall, *Productus costatus*, Sow., *Productus longispinus*, Sow., and *Productus Humboldtii*, Orb., have not as yet been stated to occur in any other but carboniferous beds. However, that is not the case with *Strophalosia Morrisiana*, King, which is one of the most characteristic fossils of the Permian period. Besides that I have collected several *Terebratulæ*, which very much resemble *Terebr. elongata*, Schloth. Thus, we may assign to the bed, in which the Cephalopoda occur, at least a certain affinity to the Permian formation, and may not be very wrong in presuming that it is situated at the limits between the Carboniferous and Permian period. Further examination of the fossils will probably show which of the affinities is greater,—that to the former, or that to the latter, formation.

Phylloceras Oldhami, *Waagen*, n. sp.

Pl. I, Figs. 1, 1*a*.

The general form of the shell is somewhat flattened, lenticular, the siphonal side is broadly rounded, the umbilicus small. The whorls are very involute, so much so that two-thirds of the outer whorl overlap the preceding one; the shell increases, therefore, very slowly both in thickness and in diameter, a peculiarity which it has in common with most of the *Arcestes*. The shell is, on the last circuit, provided with six contractions, which begin at the umbilical margin, go from there a short distance straight and radial, turn then backwards and pass over the siphonal side again with a slight bend towards the front. They are not very deep, and on the outer whorls, near the siphonal region, are barely perceptible. The umbilicus is small, deep, and with perpendicular walls.

The most characteristic distinction consists in the lobes. They exhibit a general form, very much like that known in some monophyllic

Phyllocerata, but the number of lobes is much greater than in any other known form, and their position quite different. I count fifteen lobes on each side from the siphonal to the sutural lobe, all about equal in shape, the first one, next to the siphonal lobe, being the largest, and from there they gradually diminish in size. The first seven lobes terminate with three principal fingers, the next three with two, the other five are simply pointed. However, the sub-divisions of the single lobes are very variable in shape. The siphonal lobe is broad, with two thick arms directed towards the first lateral, and one long dentated branch hanging down along the sipho. The saddles are very simple, each of them terminating with one broad rounded phyllum, diminishing in size towards the umbilicus. The strangest point of all is the position of the lobes, which in each series form a parabolical curve with two very unequal branches, the summit of the curve lying near the umbilical margin, whilst the branch proceeding to the siphonal periphery is much longer than that descending to the umbilicus. This peculiar arrangement explains the excessive number of lobes, their course being one-and-two-thirds longer than that lying along the radius of the spiral, in which direction they are arranged in other known *Ammonites*. In these, also, the longitudinal axis of each single lobe is very nearly parallel to the involution of the shell, while in the present new species the axis of the lobes forms a large angle with the involution.

This arrangement of the lobes gives such a strange and extraordinary aspect to the whole shell that I greatly hesitated to assign the species to any of the existing genera of *Ammonites*. But yet, this point alone seems not sufficient to justify the creation of a new genus; and as other monophyllic forms, like *Phyll. Jarbas*, Münst., or *sandalinum*, Mojs., were without any doubt united with Suess's genus, it seems best, also, with the species just described not to deviate from this rule until the length of the body-chamber and the shape of the aperture become known.

CERATITES CARBONARIUS, *Waagen*, n. sp.

Pl. I, Figs. 2, 3, 3*a*, 3*b*.

A flat shell, with thin compressed whorls and a very wide umbilicus. The whorls are entirely smooth except on the body-chamber, where slight folds are observable. The folds are slightly falciform, directed towards the mouth of the shell on the external margin, but very little bent towards the front on the middle of the sides. The whorls are very slightly embracing, having only a shallow impression of the preceding whorl on the antisiphonal side. The length of the body-chamber amounts to about one-half or three-quarters of a turn; the shape of the mouth is not preserved.

The form of the sutures is very simple, the saddles being undivided, the lobes finely dentated. The siphonal lobe is rather short, divided into two equal halves, each of which has two or three dentitions. The external saddle is not very high, broadly rounded; the first lateral lobe is nearly twice as long as the siphonal, with few very short and fine dentitions at the end; the lateral saddle is much higher than the external and comparatively narrower; the second lateral lobe is shorter and broader than the first, but longer than the siphonal lobe. The second lateral saddle is broad and very short, the first auxiliary lobe being already concealed by the umbilical suture.

The species resembles most *Goniatites (?) Gangeticus*, De Koninck, but has much broader and shorter lobes and saddles than the latter.

It is very rare to find specimens of *Cerat. carbonarius* with preserved lobes, as the air-chambers are mostly compressed and lost. There is at the same locality in the same bed yet another species of a *Ceratite*, with strong tuberculated folds on the sides of the compressed whorls, but the specimens I found of this species were too badly preserved to admit of an accurate description.

It requires some explanatory remarks to show why I use here the expression '*Ceratites*,' which has been abolished by most palæontologists,

since they accepted the new generic designations in the *Ammonites*, as being a genus of uncertain definition. There can be no doubt that the reasons why those gentlemen reject the genus are perfectly sound; and I myself was for a long time very doubtful whether I ought to use the expression or not, but as the word '*Ceratites*' conveys to one's mind a more limited idea of certain forms than the general expression *Ammonites*, I have chosen the first. '*Ammonites*' would immediately give to most readers the idea of a Cephalopod with saddles divided all round.

GONIATITES PRIMAS, *Waagen*, n. sp.

Pl. I, Figs. 4, 4*a*.

This species belongs to the strange group of *Goniatites*, of which *Goniatites Orbignyanus*, Vern. and Keys., is the type.

The whole shell is strongly depressed, flat, disciform. The umbilicus extremely small, the whorls enveloping each other nearly entirely. The section of the whorls is sagittiform, with a very narrow, excavated siphonal side. The cast, the only thing accessible to my investigation, is smooth, without any ornamentation. The whorls rapidly increase in height, so much so, that the height of the preceding whorl is only about one quarter of the height of the next following; the thickness, however, increases only slowly.

The lobes are most extraordinary; they are so much divided that they strongly recall the lobes of an *Ammonite*.

The siphonal lobe is divided into three very distinct parts, which are separated by deep and very narrow saddles. The middle part is a long, narrow, pointed lobe with dentitions on both sides, which lie in the excavation of the siphonal sides. It is limited on both sides by saddles, as long and not broader than itself, which are cut in on opposite sides by the numerous dentitions of the outer part of the siphonal lobe; this latter is very unsymmetrical, finishing in a somewhat leaf-shaped

point, and being limited by a very short and narrow external saddle; its situation is on the sides of the shell. The whole of the siphonal lobe is shifted towards the front, and thus appears—though in reality much longer—considerably shorter than the first lateral lobe. The lateral lobes are twelve in number, the three first of them are divided into two broad terminal, and two small lateral, partitions; in the following nine, which gradually get smaller towards the umbilicus, the lateral partitions are wanting. The saddles are all narrow and rounded.

Goniatites primas is very nearly allied to *Gon. Orbignyanus*, Vern. and Keys., but is easily distinguishable by the lobes, which are much more complicated in the Indian species. There is but little doubt that the two mentioned forms compose a separate group in themselves, which is very likely of generic value, but the materials for the present at my disposal are too small to establish the new genus. That it would be wrong simply to refer those forms to the *Ammonites* or *Clydonites* is clearly shown by the lobes, which exhibit in the siphonal lobe a quite different arrangement from any lobes as yet known in the true *Ammonitidæ*.

It is very remarkable in science, how often statements are made raising questions which are for the moment apparently solved. Then these solutions may be proved to be wrong, but still the statements have so much permanence of truth that they never again disappear entirely; but are discussed, are re-stated, and are often rejected, until finally some definite, and for the most part affirmative, solution is established. The early investigators would seem to have instinctively felt the truth, while they mistook the proofs of their statements, until later and fuller investigation detected the real proofs for the old assertion. This is exactly the

fact with the Cephalopods; since Münster, in his Memoir on St. Cassian in 1841, stated, that at this locality *Ammonites, Ceratites,* and *Goniatites* occurred in one and the same bed, the association of those three genera has been discussed *pro* and *contra* year after year, until scientific people at last believed that they had satisfied themselves that the *Ceratites* and *Goniatites* of St. Cassian were both young *Ammonites,* and that no such thing existed as an association of those genera in the same bed. That the question was nevertheless not definitively solved is shown by the specimens I collected in the Salt Range, and now, at last, one can say with confidence, that '*Ammonites, Ceratites, and Goniatites*' are associated in one and the same bed in one of the formations of India.

We have as yet little or no indication that this Cephalopoda bed of the carboniferous formation of the Salt Range is represented at any other known locality. The affinity, however, of *Goniatites primas, W.* to *G. Orbignyanus,* has led us to a comparison with the sandstones of Artinsk, which are considered by the authors, Verneuil and Keyserling, as well as by Ludwig, to be among the highest beds of the carboniferous series. Whilst a certain slight resemblance between *Phylloceras Oldhami* and *Phyll. megaphyllum,* Beyr.,* recalls the fossils of the Isle of Timor, from which island Dr. Schneider sent, to the Berlin museum, the last mentioned species together with many carboniferous fossils. There is, however, no evidence as to the stratigraphical relations of the beds in which they were found.

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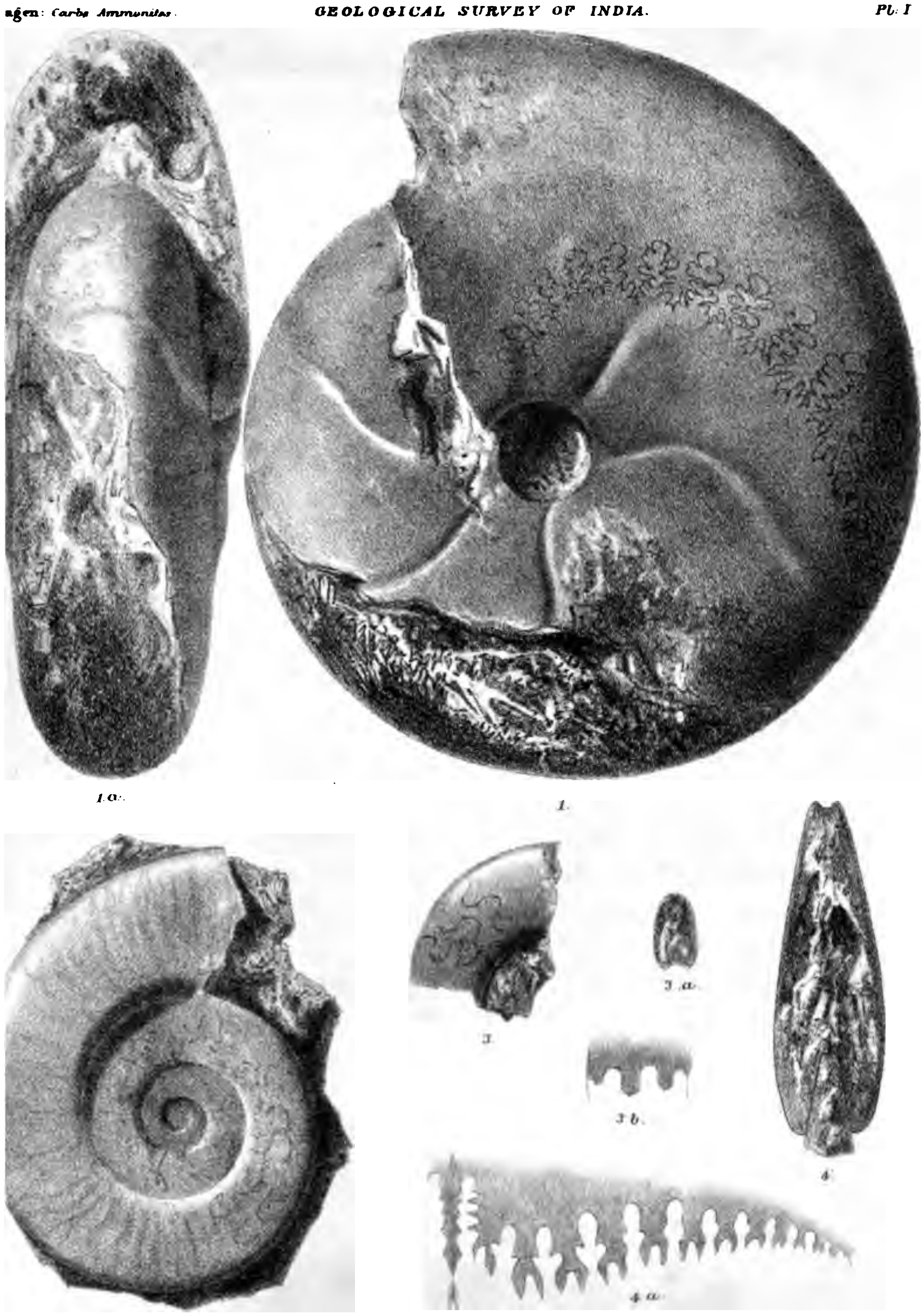
* Monatsber. Berlin Akad., 1864, p. 59.



1.1.a. PHYLLOCERAS OLDHAMI.
2.2.3.a.b. CERATITES CARBONARIUS.
4.4.a. GONIATITES PRIMAS.

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